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CONCRETE AND ROCK TESTS, MAJOR REHABILITATION OF STARVED ROCK LOCK AND DAM, ILLINOIS WATERWAY, CHICAGO DISTRICT PHASE II COMPLIANCE, SCOUR DETECTION

by

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Drilling for laboratory testing of concrete and foundation rock was carried out for the U. S. Army Engineer District, Chicago, as part of a major rehabilitation program at the Starved Rock Lock and Dam. The structures are on the Illinois Waterway. This report covers the work accomplished during the Phase II program entitled "Compliance and Scour Detection." The compliance portion of the work was conducted for purposes of determining selected characterization and engineering design parameters on any foundation materials that were
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20. ABSTRACT (Continued)

different than previously detected. A secondary purpose of the compliance work was to ascertain the base elevation of the head and taintor gate dams. The scour detection portion of the work was accomplished to determine undercutting of the dam (behind the dam) and the depth of possible scouring behind the taintor gate dam. A loosely cemented sand was discovered under a portion of the head gates dam. Direct shear tests were performed on the material and a cohesion of 0.22 tsf and an angle of internal friction of 27 deg were obtained from the test results. The base of the head and taintor gate dam was found with borings to be significantly different than that shown on original working drawings. Of 26 borings through the head and taintor date dam, 20 showed the base elevation of the dam to be deeper than that shown on the working drawings. Six borings through the head gate dam showed the base of the dam to be resting on the loosely cemented sand and as much as 5.3 ft above the base elevation shown on the original working drawings. Scour borings behind the dam showed no undercutting at selected locations. No covered scoured areas were detected at selected locations. A study of the foundation condition was made.

PREFACE

This testing program entitled "Concrete and Rock Tests, Major Rehabilitation of Starved Rock Lock and Dam, Illinois Waterway, Chicago District, Phase II Compliance, Scour Detection" was conducted for the U. S. Army Engineer District, Chicago. The compliance work was authorized by DA Form 2544 No. NCC-IA-77-31, dated 5 April 1977; the scour detection work was authorized by DA Form 2544 No. NCC-IA-78-57, dated 7 June 1978.

Drilling was conducted under the direction of Mr. M. A. Vispi by members of the staff of the Geotechnical Laboratory (GL) of the U. S. Army Engineer Waterways Experiment Station (WES) during the period June 1977 through July 1977 for compliance holes and July 1978 through September 1978 for scour holes. Laboratory tests were performed at the Structures Laboratory (SL) and the GL during the period September 1978 through November 1978 under the direction of Messrs. Bryant Mather, Chief, Structures Laboratory, and J. M. Scanlon, Chief, Engineering Mechanics Division. Mr. G. P. Hale supervised the laboratory testing conducted in the GL; Mr. R. L. Stowe was Project Leader and was assisted in performing laboratory work at the SL by Messrs. F. S. Stewart and J. B. Eskridge and Ms. B. A. Pavlov. This report was prepared by Mr. Stowe and Ms. Pavlov.

The Commanders and Directors of WES during the conduct of the investigation and the preparation and publication of this report were COL J. L. Cannon, CE, and COL N. P. Conover, CE. Mr. F. R. Brown was Technical Director.

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CONTENTS (Continued)

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* Copies of Appendixes B, C, and D may be obtained from U. S. Army Engineer District, Chicago, 219 South Dearborn St., Chicago, Illinois 60604.

CONVERSION FACTORS, INCH-POUND TO METRIC (SI) UNITS OF MEASUREMENT

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
degrees (angle)	0.0174533	radians
feet	0.3048	metres
feet per second	0.3048	metres per second
miles (US statute)	1.609344	kilometres
pounds (force) per square inch	0.006894757	megapascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
square feet	0.09290394	square metres
tons (force) per square foot	0.09511274	megapascals

CONCRETE AND ROCK CORE TESTS, MAJOR REHABILITATION OF STARVED ROCK LOCK AND DAM ILLINOIS WATERWAY, CHICAGO DISTRICT PHASE II COMPLIANCE, SCOUR DETECTION

PART I: INTRODUCTION

Location of Study Area

1. The Starved Rock Lock and Dam site is located some 8 miles* west of Ottawa, Illinois, in LaSalle County, Illinois. The site is near mile 231 on the Illinois River; the approximate driving distance is about 85 miles southwest of Chicago.

Background

2. At a meeting held at the offices of the U. S. Army Corps of Engineers Chicago District (NCC),** on 11 February 1977, representatives of the Structures Laboratory (SL) and the Geotechnical Laboratory (GL) of the Waterways Experiment Station (WES) were requested to submit a proposal for work to assist the Chicago District in connection with concrete and rock exploration and laboratory testing. The work was accomplished in two phases. Phase I work concerned concrete and rock exploration and laboratory testing for a major rehabilitation of the Starved Rock Lock and Dam (resurfacing, stabilizing lower approach wall with grouted prestressed tendons, etc.). The Phase I work is completed and results ofthe work are given in Reference 1. Phase II work concerned drilling and laboratory testing to comply with certain Office, Chief of

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* A table of factors for converting inch-pound units of measurement to metric (SI) units is presented on page 4.

** The Chicago District is in the North Central Division, and the office symbol is NCC.

Engineers (OCE), and North Central Division (NCD) comments as outlined in Reference 2. A study of the foundation condition was also made.

3. The Phase II work involved drilling and then testing of concrete and bedrock for purposes of obtaining certain characterization properties and engineering design properties as outlined on pages 53 and 54 in Reference 2. Bedrock would be tested if found to be significantly different than bedrock tested and reported on in References 1 through 3. The District will check previous structural stability analyses if certain rock properties differ significantly from those reported in Reference 2 or if new weaker materials are found and tested.

4. Subsequent to the February meeting, a scour detection study was initiated by the District as part of its ongoing investigation at Starved Rock Lock and Dam. A similar study was conducted at the Brandon Road and Dresden Island Dams. In September 1977, WES was asked to assist the NCC by drilling bedrock cores in scoured areas behind the taintor gate dam. Careful examination, together with knowledge of the local geology, could possibly indicate boulders within or covering scoured-out holes. Soundings made in 1959, 1974, and those made in 1977 showed relatively deep scouring just downstream (D/S) of taintor gate bays 8, 9, and 10.

5. At the completion of the Phase II and scour detection studies, recommendations were made by the District to drill additional borings in the head gate and taintor gate sections. These borings were necessary to verify the base elevation of the dam and confirm the type of bedrock beneath the dam. Borings were made and the information gathered from them is incorporated in this report. This report presents the results of the Phase II study and the results of the scour detection study described in paragraph 4. Geological information obtained from these two studies and the Phase I study was integrated with geological information gathered from References 2 through 6 to make an evaluation of the foundation condition. Attempts were made to gather additional information on the foundation condition. The State of Illinois, the NCC, and the Joliet Project Office (representatives of the operator, which is the U. S. Government), and the Illinois Geological Survey were contacted.

Little geological information was obtained dating back to the time of the actual excavation for the lock and dam.

Objectives

6. The objectives of the Phase II study (complying with certain OCE and NCD comments) were to:

- a. Conduct limited drilling for laboratory testing of concrete and foundation rock. The rock would be tested if found to be different than rock previously observed at the lock and dam site.
- b. Make an analysis of tests conducted, a summary of the concrete condition at specific locations, and an evaluation of the foundation using available geological information.

The objective of the scour detection study was to ascertain the top of sound rock and the presence of boulders at specific locations behind the taintor gate dam structure.

Scope

7. The compliance and scour detection drilling (4 and 18 borings, respectively) was accomplished using a WES drilling crew, plant, and supplies. NCC Construction and Operation Division supplied the floating plant assistance for drilling on the river. A Bureau of Reclamation geologist on contract to WES logged and preserved the core for testing during the compliance drilling. A WES geologist performed similar duties during the scour detection drilling. The core was transported to the WES as soon as feasible after drilling was completed for each job.

8. The objectives of the compliance study were accomplished by drilling concrete and bedrock core and by conducting characterization property tests (unit weight, compressional wave velocities, and compressive strength tests) and engineering design tests (moduli, Poisson's ratio, and direct shear tests). Direct shear tests were conducted on intact core and core containing thin shale seams.

9. The scour detection objective was accomplished by drilling and then performing a detailed examination of the bedrock to determine if the drilled rock had been recently disoriented. Information obtained during drilling was used in determining if scoured holes were present at selected drill locations.

10. A study was made to consolidate and evaluate engineering information, geologic and boring data, and laboratory test data as they relate to the foundation conditions at the Starved Rock Lock and Dam. Available construction and engineering data records were reviewed.

PART II: DRILLING AND EXPLORATION

Previous Exploration

11. From available information it was learned that 36 borings were made by the State of Illinois in 1921 in connection with original construction of the lock and dam. Forty percent of the borings were drilled to a depth of about 25 ft, 30 percent to a depth of about 40, and the remaining 30 percent up to depths of 65 ft. The boring logs do not provide for an engineering evaluation of the bedrock or the overburden; detail is lacking from graphic representation of these borings. The top of bedrock, the type of rock encountered, and the top of a sandstone bed in dolomite is in good agreement with the more recent information gathered by the NCC and the WES drilling efforts.

12. In addition to the original exploration conducted by the State of Illinois, drilling was performed by the NCC in 1971-1972 and in 1974 through contract drilling by a private concern; the WES conducted two separate drilling operations in 1977 and 1978.

13. The 1971-1972 drilling by the NCC was for purposes of:

- a. Obtaining a foundation appraisal of the bedrock and backfill.
- b. Providing design parameters for use in a structural stability analysis.

Thirteen borings were put down, 11 in the backfill adjacent to the lock and 2 in front of the taintor gate dam section; 7 borings were in support of the foundation appraisal and 6 for purposes of installing piezometers. Six borings were drilled into bedrock while the others were put into overburden. Nineteen borings were drilled on the land side of the lock in 1974 in connection with the proposed Duplicate Locks program.[3] Foundation core was sampled for purposes of conducting laboratory tests appropriate for those bedrock conditions revealed in the core. A summary of the foundation condition was also made during the Duplicate Locks investigation.[3]

14. The WES drilling was in support of the Phase I major rehabilitation (see paragraph 2) of this report. During the rehabilitation study nine vertical borings were put into bedrock. Five borings were put through and behind the lower approach wall; two went through the concrete wall into bedrock and three were put down in the backfill adjacent to the wall. Four borings were put down into bedrock behind (downstream) of the taintor gate dam section.

Current Drilling

15. Drilling equipment consisted of an Acker Toredo Mark II skid-mounted rotary drill rig. A Diamond Core Drill Manufacturers Association standard 6-in. by 7-3/4-in. double tube swivel tube core barrel was used with diamond bits to obtain the concrete and bedrock core. Access to the drill holes was by a marine floating plant and for holes on top of structures by crane. Floating plant was supplied by NCC. Continuous samples were obtained in all borings. Eight-inch casing was set in the bedrock when necessary to keep a boring open.

16. Twenty borings were drilled during the compliance phase of the study; 4 were scheduled originally and 17 added at the end of the study to confirm base elevations. Of the four borings originally scheduled to be drilled during the compliance study, only three were completed, as L-1 (through land lock wall) was drilled during the Phase I work (see paragraph 21, Reference 1, for explanation). The remaining three borings, D-11, D-12, and D-13, were drilled through the head gate dam structure, the sixth taintor gate pier, and the fixed dam section, respectively. Of the 17 borings added at the end of the compliance study (D-60 through D-76), 1 was drilled in the ice chute bay area, 3 in taintor gate bays, and 17 in the head gate dam section.

17. Boring locations for the scour detection study were assigned within the scoured areas as indicated by profiles of soundings made by the NCC. Appendix A contains the graphical representations cf the scour soundings made by the NCC. Borings were assigned in areas where high

peaks and low valleys were indicated on the profiles of soundings. Generally, one boring per taintor gate bay was drilled.

18. The scour detection drilling consisted of 18 borings. Seventeen borings were put down behind the dam and one in front; the one in front was drilled to provide geological information for an upstream-downstream geologic cross section. Fourteen borings were located from 10 to 42 ft D/S from the vertical D/S face of the taintor gate piers; one was drilled 2 ft U/S from this reference point; and two were located 100 ft D/S of this reference point. One boring was located 27 ft U/S of the nose of pier No. 11 and about 15 ft to the north of pier No. 11. Five of the 18 borings went through the concrete apron; the concrete averaged 12 ft in thickness. A majority of the borings were drilled to a depth of about 10 ft; eight borings ranged in depth from 21.5 to 70.1 ft. Most of these deeper borings were taken 25 ft into bedrock.

19. Borings for installing extensometers were drilled in the summer 1978, and information from the borings is included in this report for completeness. The instrumentation drilling consisted of seven borings. Three horizontal borings were drilled through taintor gate pier No. 11 (southernmost pier) continuing into the abutment. The concrete varied in thickness from 7.0 to 8.5 ft; these three borings were taken to 50-ft depths.

20. Total footage drilled during the compliance study, the scour study, and the instrumentation study was 1159.0 ft. Of this total footage, 538 ft of concrete, 606 ft of bedrock, and 15 ft of silt were drilled. Selected portions of the concrete and all the bedrock were preserved for possible laboratory testing during the compliance drilling. The concrete drilled during the scour study was not wrapped nor was the badly broken bedrock; almost all intact bedrock was preserved.

21. Procedures for handling the field samples and preserving core for testing were the same as presented in Reference 7. Color photographs of all core recovered are included in a notebook as Exhibit A to this report for the scour detection core. Photos for the core recovered during the compliance drilling are contained in Exhibit A to the Phase I major rehabilitation report for Starved Rock (see Reference 1). Exhibits B

and C contain the field core logs for the compliance and scour detection studies; the three exhibits are on file at the NCC.

22. Core recovery was good in the concrete and bedrock for the borings in the lower approach wall, lock structure, ice chute, and taintor gate structure. The average core recovery, using total footage of concrete and bedrock, was 98.5 percent. Core recovery in the head gate structure, using total footage of concrete and bedrock, was 94.8 percent. Relatively speaking, there is little difference between the recovery in the head gates area and the rest of the lock and dam structures. However, when core recovery in the head gate area is based on bedrock footage, a significant difference exists. Using only bedrock footage from the head gate structure, core recovery is 85.2 percent. The core loss occurred in a very friable, loosely cemented sandstone that is fine-grained and varied in color from black, dark gray to light gray, green, and white. A 2.9-ft loss in one boring in the head gates structure occurred at the concrete-bedrock interface. Two other borings show core loss beginning at 0.7 and 0.9 ft from the interface. An average loss of 2.2 ft occurred in 13 of the 15 borings in the head gate structure.

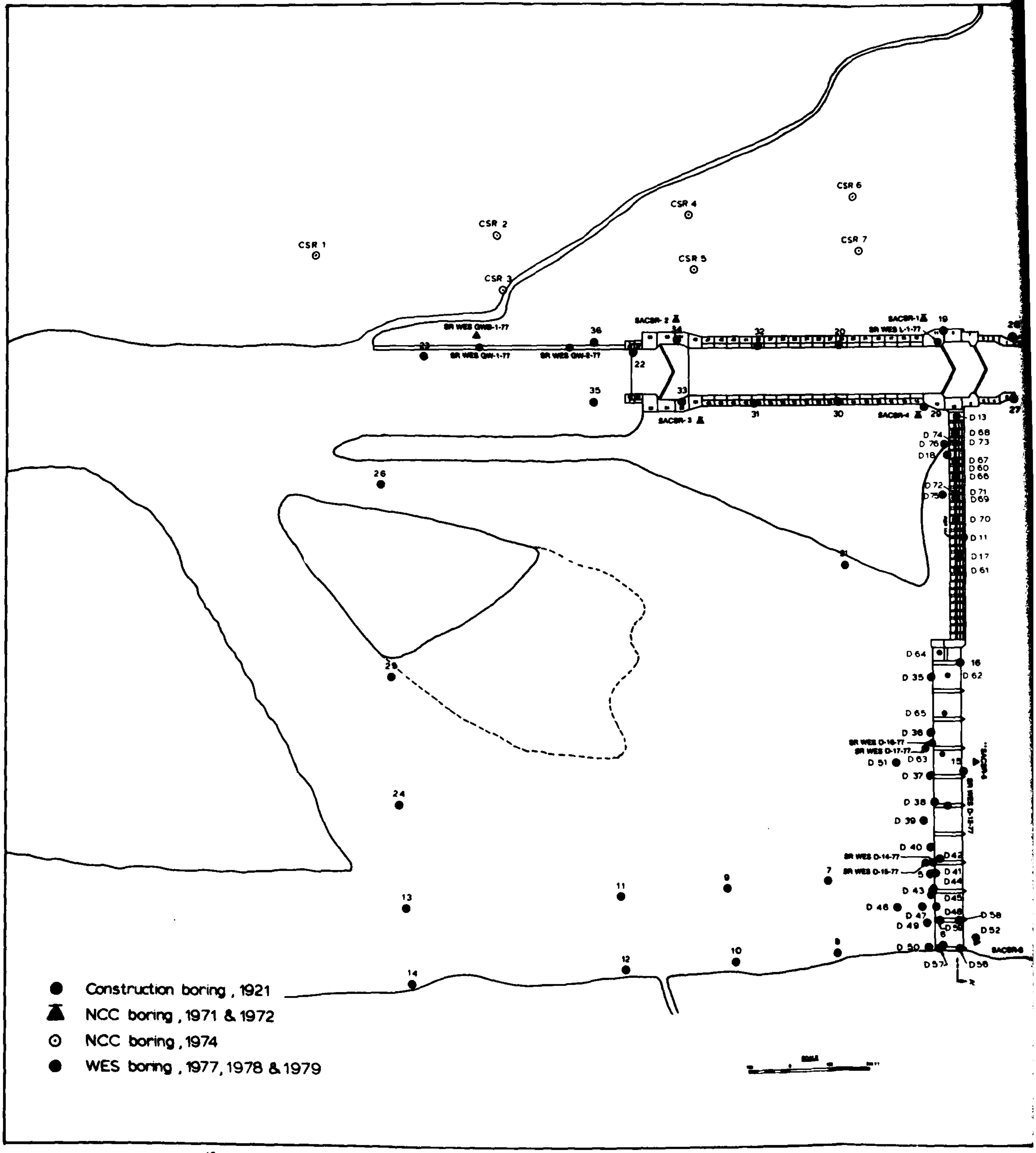
23. Available information from seven projects at Starved Rock for which borings were made, the number of borings, and the boring series numbers are given in the following list:

Project (Agency)	Year	No. of Borings	Boring Series No.
Original Construction (State Illinois)	1921	36	1-36
Structural Stability Analysis (NCC)	1971-1972	7	SACSR-1, through -7
Duplicate Locks (NCC)	1974	19	CSR-1-74 through -19-74
Phase I, Major Rehabilitation (WES)	1977	9	SR WES GW-1, 2-77 SR WES GWB-1, through 3-77 SR WES D-14 through D-17-77
Phase II, Compliance (WES)	1977	4	SR WES L-1-77 SR WES D-11 through D-13-77

Project (Agency)	Year	No. of Borings	Boring Series No.
	1979	17	SR WES D-60 through D-76-79
Scour Detection (WES)	1978	18	SR WES D-35 through D-52-78
Left Dam Abutment Instrumentation (WES)	1978	7	SR WES D-53 through D-59-78

24. Table 1 is a listing under each project of the above-listed borings; the State of Illinois borings are not included due to lack of information. The following information is presented for each boring: the boring type symbol, the location by structure, the elevation of the top of boring, the elevation top of rock, and the elevation bottom of rock, and the date when the boring was started.

25. Figure 1 shows the relative location of every boring listed in Table 1 plus the original construction borings. More precise locations for the NCC and WES borings are shown in key plan views on the log of borings. The logs of borings for the compliance and scour detection studies are shown in profile in Plates 1 through 7g. The logs of borings for selected holes drilled during the Phase I rehabilitation study are also presented in Plates 1 through 4.



CSR 1
CSR 2
CSR 3
CSR 4
CSR 5
CSR 6
CSR 7
SACBR-1
SACBR-2
SACBR-3
SACBR-4
SR WES GWB-1-77
SR WES GW-1-77
SR WES GW-2-77
SR WES L-1-77
SR WES D-16-77
SR WES D-17-77
SR WES D-14-77
SR WES D-15-77
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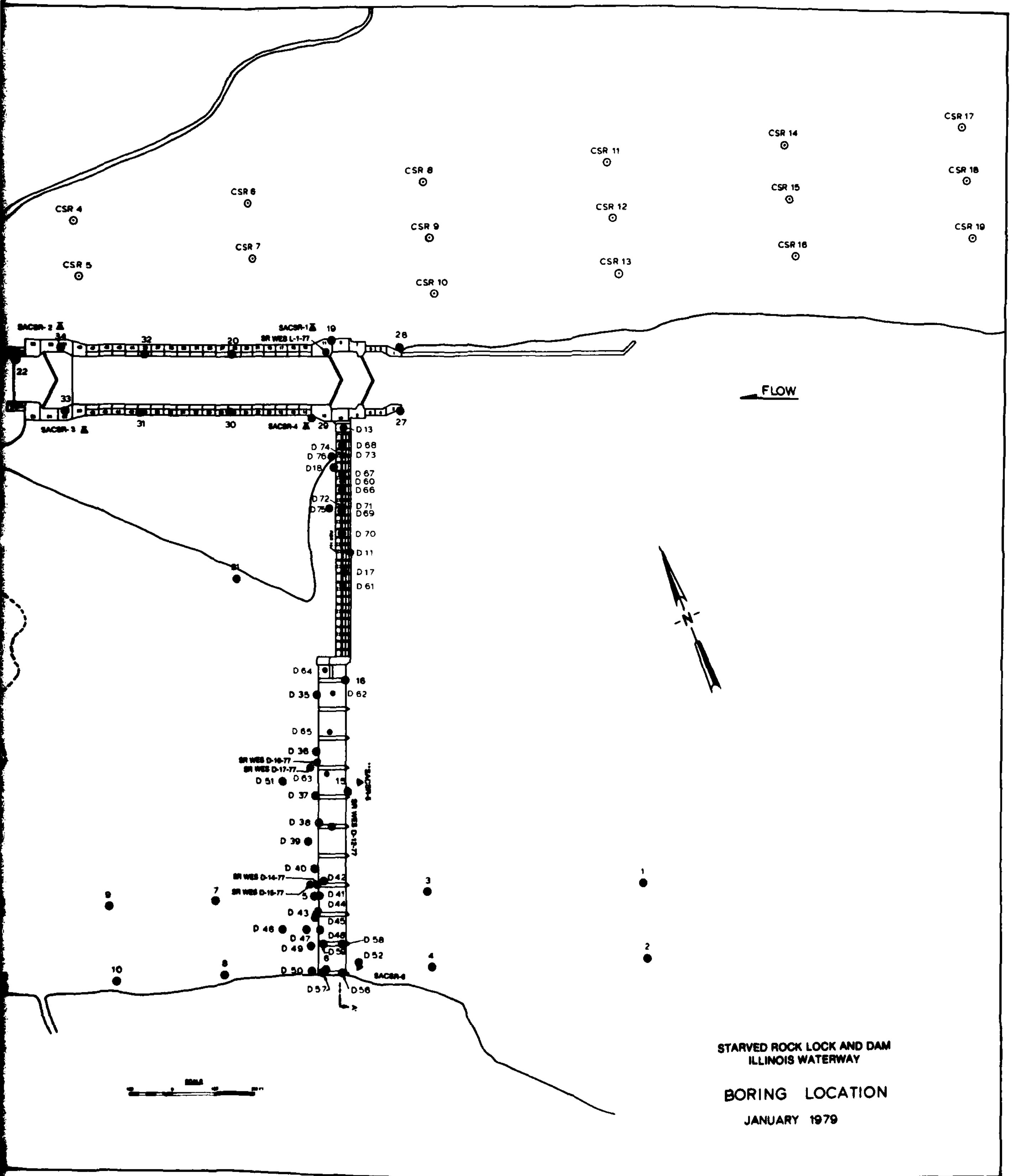
Construction boring, 1921
NCC boring, 1971 & 1972
NCC boring, 1974
WES boring, 1977, 1978 & 1979



STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

BORING LOCATION

JANUARY 1979

FIGURE 1

PART III: SCOUR DETECTION RESULTS

26. The scour detection drilling supplied information about the top of sound rock at specific locations behind the taintor gate dam. Geological information obtained from the borings was used along with similar information from other borings at the lock and dam site in making an evaluation of the foundation. This part of the report deals with the top of rock and the scouring. In response to inquiries made of the Chicago District and the Joliet Project Office, it was learned that no information was available concerning the possible filling of scoured areas at the Starved Rock Dam. Corps personnel contacted did not know whether the State of Illinois (original owners) or the Corps placed any stone or other fill behind the dam to fill scoured areas.

27. No evidence of displaced or recently (post-dam construction) disoriented rock blocks was found during the drilling of the scour detection borings. The scour borings showed that the top 4 ft of bedrock consisted of friable sandstone, loose material or hard dolomite and sandstone. Of the 17 borings drilled behind the dam, 5 contained friable sandstone, 4 contained loose material, 2 contained hard dolomite, and 1 contained moderately hard sandstone. The remaining five borings were drilled through concrete. The loose material includes sand, sandstone, dolomite, metal pieces, and metamorphic rocks. Some of the material is local bedrock (the sandstone, sand, and dolomite). The remainder is rock and debris presumably transported by the river. The loose material is located downstream of the taintor gates 9 and 10. The thickest accumulation (4 ft) of this material was found 17 ft downstream of the apron of gate No. 10.

28. The NCC conducted scour soundings in 1959, 1974, and again in 1977. In comparing the results of the current scour detection study and the 1977 sounding results, large discrepancies are seen. Depths of scouring were compared whenever a WES drill site intersected a profile traverse (taken perpendicular to the dam) made by the NCC. Of the 11 borings drilled directly into bedrock, only 2 top of rock elevations matched the 1977 sounding elevations. Four borings are within 2 to 3 ft,

four borings are within 7 to 9 ft, and one boring is within 13 ft of the 1977 sounding elevations. When the same WES data is compared to the 1974 soundings, the difference is considerably smaller for a number of comparisons; i.e., the largest difference (13 ft) becomes 1 ft. The NCC and WES top of apron elevations are within several inches, which indicates both parties used the same reference elevations. The discrepancies in elevations between the previous soundings and the current WES work could be attributed to the highly irregular surface of the bedrock just downstream of the dam section. This is somewhat reasonable due to the presence of the friable and sometimes highly fractured sandstone in this area. Large discrepancies could easily occur with high narrow ridges running perpendicular to the dam. For example, if one profile line was run several feet to one side of a previous line, and one line was on a high ridge while one line was in a trough, then large differences in elevations would be observed.

29. Five borings were drilled through the concrete apron into bedrock for purposes of detecting possible undercutting of the apron and ascertaining apron thickness. The contact between concrete and bedrock was tight in all five borings, i.e., borings D-38, D-41, D-42, D-43, and D-48. Borings D-41, D-42, and D-48 showed the concrete to be resting directly on competent dolomite. Boring D-38 contains a thin green clay seam and D-43 contains a thin green shale seam at the contact.

30. No undercutting of the concrete apron was found in the five borings drilled through the apron. The concrete apron thickness shown on original working drawings is 5-ft minimum. The five current borings through the apron show the concrete to be from 10.7 to 14.3 ft thick. The thickest concrete was found in borings D-41 and D-42 located in gate bays 8 and 7, respectively. By superimposing the original construction drilling core record from boring No. 5 in gate 8 (see Plate 13), a 9-ft thick clay seam or lens is shown from el 417 to 426 ft. It is evident that the thick clay in this area was removed during construction, based on the fact that the base of the apron was founded at el 415.5 and 416.0 ft as shown in D-41 and D-42, respectively. It is reasonable to assume that the taintor gate pier 8 was founded at the same elevation as the apron.

31. Of concern during the Phase I work was the 1-ft thick clay bed or lens found in the St. Peter sandstone in boring D-14-77 between el 411 and 412 ft. The bed or lens is located 4-ft downstream of taintor gate No. 8 (pier 8 was referred to as pier No. 4 in Reference 1). The two borings D-41 and D-42 were drilled to investigate the possibility that the 1-ft thick clay bed or lens extended upstream under the pier and/or concrete apron. The St. Peter sandstone was missing just to the north and just to the south of pier 8 in borings D-41 and D-42. It is, therefore, assumed that the clay found in D-14-77 was either part of the clay body that was removed during construction, or is a clay lens of limited extent. A few thin (<0.1 ft) clay seams are present in the dolomite recovered from borings D-41 and D-42. However, they occur about 4 ft below the concrete-bedrock contact.

PART IV: GEOLOGICAL CHARACTERISTICS

Backfill

32. The backfill behind the lower approach wall and the land lock wall is described in References 1 and 2. The backfill is probably spoil from the lock and dam excavations and consists of a mixture of clay, sand, gravel, and boulders. Recommended design values for the backfill are presented on page 18 in Reference 2.

Bedrock Stratigraphy

33. The bedrock beneath Starved Rock Lock and Dam consists of the St. Peter sandstone and the Shakopee dolomite Formations of Ordovician Age. The St. Peter Formation is represented at Starved Rock by two of its members, the Tonti and Kress sandstones. The Tonti is a fine grained, well sorted, friable or weakly cemented, porous sandstone; the Tonti recovered in the head gate dam section varies in color from dark gray to gray, green, and white. The sandstone has colored layers. The sandstone in contact with the concrete in the head gate dam is dark gray to gray, fine grained and moderately friable to friable; occasional lenses of loose sand were found and zones of core loss were common. Beneath and interbedded with this layer is a light green to green, fine-grained sandstone with 5 to 10 percent clay mixed within the sandstone. Beneath the green layer is a light gray to white, fine grained sandstone with occasional interbedded thin black layers just above the underlying Shakopee dolomite. The Tonti contains few or no impurities. It contains some crossbeds. The Kress Member is a coarse rubble or conglomerate of chert in a matrix of sand, clay, or shale, and is interpreted as a residue from the solution of the underlying cherty dolomite and sandstone.

34. The Shakopee Formation is a thin to medium bedded, fine-grained, argillaceous to pure, light brown to light gray dolomite. It contains green to light gray clay and shale in seams that range from a thin film to 1.5 ft in thickness. The term "filled parting," or just

"parting," is used interchangeably with the term "seam." About 80 percent of the filled partings range from a film to < 1/8 in. in thickness; about 10 percent of the filled partings range from 1/8 in. to < 1/2 in. in thickness; and about 10 percent are > 1/2 in. in thickness. The surface of the partings (host rock containing the filler material) is a natural discontinuity, normally a bedding plane separation. The two surfaces containing the filler are generally undulatory in nature, peak to valley distance is about 1/2 in., and have periods of about 2 in. The peaks are generally narrow, pointed asperities that are interlocked. About 80 percent of the film to < 1/8-in. thick partings are not uniformly thick; rather, the filler coats about 60 to 70 percent of these parting surfaces. The filled partings from 1/8 in. to < 1/2 in. in thickness generally have parting surfaces that are 70 to 100 percent coated by the filler. Observations of the thicker seams reveal that their parting surfaces are coated 100 percent of the time. The thinner seams are considered to be discontinuous across the foundation. A few of the thicker seams can be traced over several hundred feet.

35. The Shakopee also contains several beds of medium grained sandstone and small quantities of buff-colored siltstone. The sandstone beds are usually thin and discontinuous, with the exception of one continous 4-ft thick sandstone bed. The Shakopee also contains chert found in discontinuous bands and isolated nodules. The chert is massive but at times becomes oolitic or partly sandy. The Shakopee contains beds of conglomerate and breccia. These appear to have formed essentially in place. Algal reefs are found in the borings and range in thickness from isolated fragments found in the conglomerate to 2 ft thick.

36. The contact of the St. Peter and the Shakopee Formations represents a major unconformity. This feature was examined in detail in the resurfacing report.[1] A general columnar section of the St. Peter sandstone and Shakopee dolomite found in the general vicinity of the lock and dam is presented in Figure 2.

NORTHERN ILLINOIS				
Group	Fm		Member	Feet
ANCELL	Glenwood		Harmony Hill	0-27
ANCELL	Glenwood	Nokomis 0-5	Loughridge	0-22
ANCELL	Glenwood	Nokomis 0-5	Daysville	0-75
ANCELL	Glenwood	Nokomis 0-5	Kingdom	0-40
ANCELL	St. Peter		Starved Rock	0-235
ANCELL	St. Peter		Tonti	30-300
ANCELL	St. Peter		Kress	0-170
PRAIRIE du CHIEN	Shakopee Dol.			0-2000

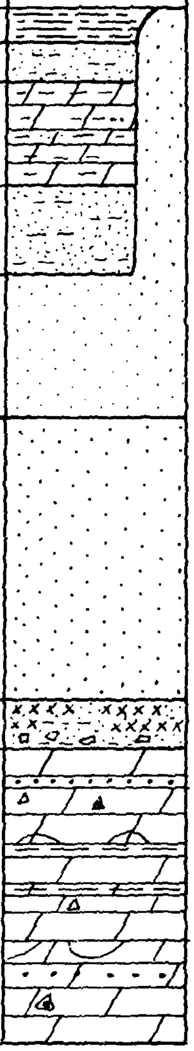


Figure 2. Columnar section typical of the Starved Rock Lock and Dam area

Geologic Cross Sections

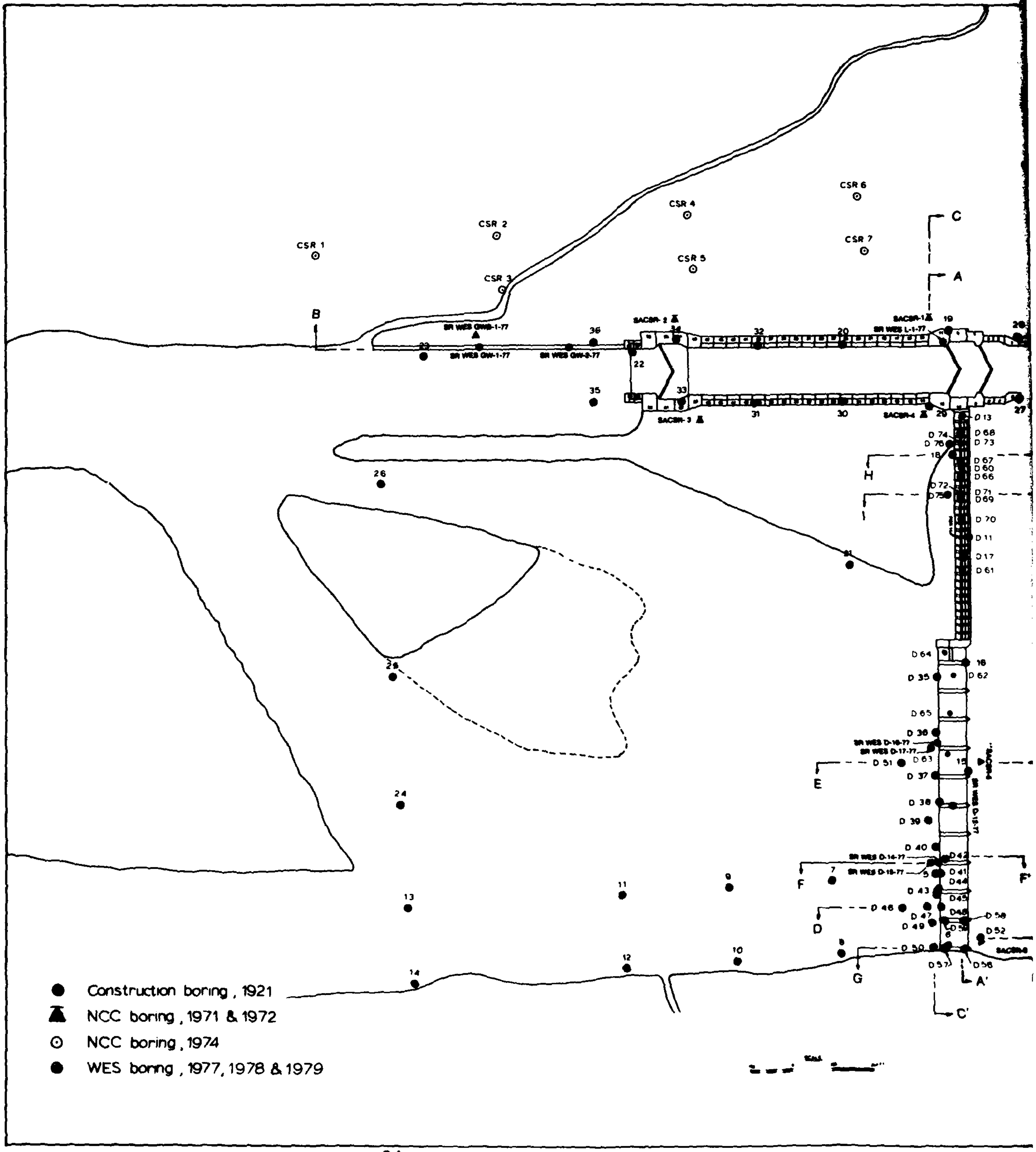
37. The cross sections were drawn with the intention of not showing every lithologic and structural feature observed in the core. To do so would unnecessarily clutter the cross sections. A detailed description of the core is given in the log of borings (Plates 1 through 7g).

38. The locations of the nine cross sections selected to illustrate the foundation conditions at the lock and dam are shown in Figure 3. The cross sections were drawn incorporating selected borings from the seven projects listed in paragraph 23. The following tabulation gives the cross sections, general location of section, borings in sections, and plate number of sections.

Section	General Location	Borings in Sections	Plate No.
A-A'	Dam axis	SACSR-1, SACSR-4 through 6, L-1, D-11 through 17*	8
B-B'	Lock and lower guide wall	SACSR-1 through 4, SACSR-7, SACSR-4, SACSR-7, GWB-1, GW-1 and 2, L-1	9
C-C'	Dam axis	SACSR-1 and 4, L-1, D-11 through 13, D-35 through 43, D-45, D-48 through 52, D-60 through 70, D-71 and 73	10
D-D'	Taintor gate dam	D-46 through 49, D-52, D-58 and 59	11
E-E'	Taintor gate dam	SACSR-5, D-16 and 17, D-51	12
F-F'	Taintor gate dam	5, D-14 and 15, D-41 and 42	13
G-G'	Taintor gate dam	6, D-50, D-52, D-56 and 57	14a
H-H'	Head gate dam	D-73 and 74, D-74	14b
I-I'	Head gate dam	D-71 and 72, D-76	14c

SACSR, Stability Analysis Civil Starved Rock; L, lock; D, dam; GW, guide wall; B, backfill.

* The first five letters and the last two numerals have been omitted from the WES boring numbers for purposes of clarity.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CSR 2
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CSR 6
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D 73
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D 66
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D 52
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F
F'
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7
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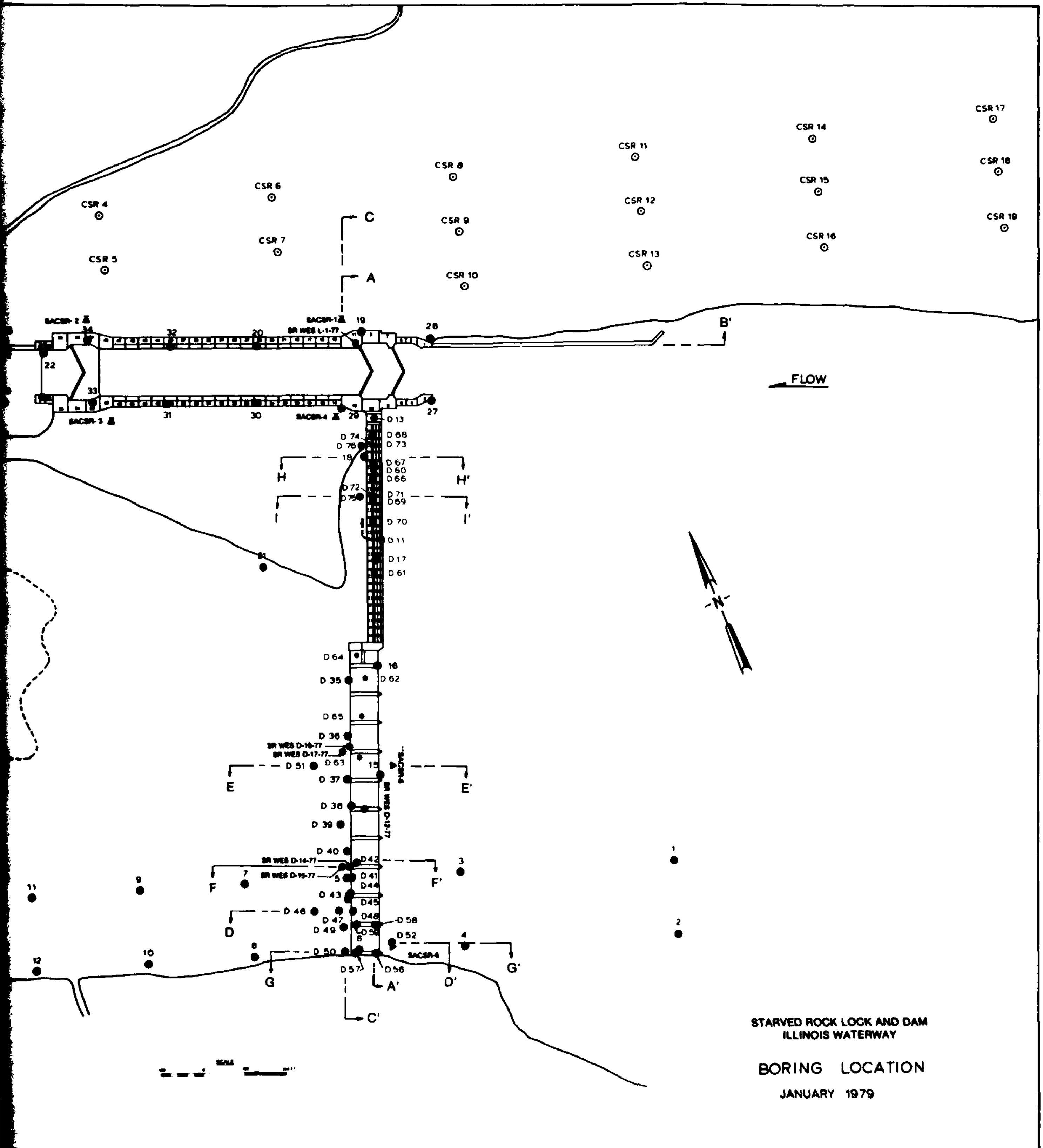
Construction boring, 1921
NCC boring, 1971 & 1972
NCC boring, 1974
WES boring, 1977, 1978 & 1979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FLOW
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SACSR-1
SACSR-2
SACSR-3
SACSR-4
SACSR-6
SR WES L-1-77
SR WES D-16-77
SR WES D-17-77
SR WES D-18-77
SR WES D-14-77
SR WES D-15-77
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D 56
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
BORING LOCATION
JANUARY 1979

FIGURE 3

2

The detailed location of the borings can be found in the plan view at the top of each plate. Note that the profiles are nonlinear since they incorporate borings placed near to as well as on the lock and dam structures. These sections give a good overview of the bedrock beneath the installation. Detailed drawings of the borings are found on the log of boring sheets.

39. The above cross sections show the major rock types and include selected features such as reefs, fault zones, solution cavities, beds and lenses of shale, clay, sandstone, dolomite, and chert greater than 2 ft thick. It is difficult or impossible to trace most of these potentially weak features across the foundation at Starved Rock Lock and Dam. For example, thin clay and shale seams found in one or more borings are not continuous in adjacent borings and are therefore considered as discontinuous features local in extent.

40. A shale bed found in a number of boreholes may be continuous over the area of study. Plate 12 illustrates one case where it was reasonable to connect up a shale bed within the St. Peter sandstone. The bed is traced over a distance of about 200 ft and is found at el 423 to el 429 within this 200-ft distance; the unit ranges in thickness from 1.0 to 1.5 ft. Other shale units are found at elevations ranging from 414 to 435 ft, but it is not reasonable to connect these units up. A shale bed in the Shakopee could be continuous in the fixed dam and the first one-half section of the head gate dam. The shale is found at el 426 to 432 ft and ranges in thickness from 0.5 to 3.5 ft. It is not connected between borings because it is not found in some of the borings in this area.

41. There were three other features observable in the cross sections which may be continuous over the extent of the lock and dam. The first feature is a small displacement fault zone in the Kress sandstone. The second is a line of solution cavities in the Shakopee, and the third feature is the conglomerate and breccia found principally above the 4-ft sandstone layer in the Shakopee. These features will be discussed in greater detail in paragraphs in the Bedrock Structural

Characteristics Section. One feature that is traceable over the area of study is a 4-ft sandstone layer in the Shakopee dolomite; the unit can be seen in Plates 9 and 10.

Bedrock Structural Characteristics

42. Bedrock structural characteristics relevant to the foundation are presented in Plates 15, 16, and 17 for the scour borings. Structure sections were not drawn for compliance cores because structural characteristics of these cores were similar to the structural features of the core described in the Phase I program[1] and in the scour program.

43. The nearest major regional structure is the Sandwich Fault Zone; it is described in Reference 1. As described in Reference 3, joint traces and the orientation of the Sandwich Fault shows a subparallel relationship. However, a study of surface joint exposures over a large area would be necessary to conclusively relate the fault zone orientation to the joint orientation. Such a relationship within the structural fabric of the area is probable. This does not imply specific fault activity at the site. Boring information from across the lock and dam foundation does not show evidence of any major faulting. Small displacement faulting is observed as discussed below.

44. Small displacement faulting and slickensides in the bedrock are common occurrences. The longest measurable displacement along a fault is 1.5 ft in D-16. The boring is located approximately 4 ft D/S of gate No. 3. Slickensides occur in the clay and shale seams which are abundant in the bedrock. Slickensides occur on both low and high angle fracture surfaces. There exists in the Kress sandstone a zone of small multiple faults which occur in the elevation interval 420 ft to 425 ft; displacement is on the order of 0.5 ft. These small faults are present in borings in front of and behind the dam sections. The small displacement faulting observed in the core is considered not to be a problem in terms of structural stability. The cause of the faulting is not known. Soft sediment deformation or unloading phenomenon of the valley after glaciation could have caused the faulting.

45. Dips in local bedding range from < 1 to 12 deg when measured between boreholes at the St. Peter/Shakopee contact. A 0.5-deg dip to the southwest was measured on the 4-ft sandstone bed in the Shakopee dolomite. This dip is consistent with regional dips cited in the literature. The 12-deg dip range in local bedding is explained by the fact that the St. Peter/Shakopee contact marks a major unconformity, as mentioned in the Bedrock Stratigraphy, where the St. Peter rests on an irregular erosional surface caused by solution of the underlying cherty dolomite.

46. The 4-ft sandstone layer in the Shakopee dips slightly to the southeast. The elevation of the top of the layer is highest at the lock (414 ft) and dips to 401 ft near the southern end of the dam. Within the layer, as shown in the scour borings, is a disturbance in which sandstone was vertically injected into sandstone. This is most noticeable where the original sandstone is finely layered or where shale seams are present in either body of sandstone. There are also occurrences of sandstone being injected into dolomite (D-51, el 402; D-42, el 400; D-41, el 408; and D-49, el 407). There is one instance of shale injected into dolomite (D-48). This type of structure is possibly related to the same forces which caused the formation of conglomerates and breccias in the dolomite directly above the sandstone layer; see paragraph 48.

47. The Shakopee dolomite is dense to porous in nature. It contains vuggy areas and, in several locations, has developed solution cavities up to 0.4 ft deep. These cavities occur primarily in a band from el 408 ft to 412 ft. The majority of cavities were revealed in core obtained from behind and within taintor gate bays 7, 8, 9, and 10. Gate 10 is adjacent to the left dam abutment.

48. Borings behind the dam revealed that the Shakopee below the base elevation of the dam contains much more conglomerate and breccia than was previously believed. The majority of the conglomerate and breccia occurs above the 4-ft sandstone layer in the Shakopee. The conglomerate is usually a dolomite aggregate in a dolomite matrix but may occur as a dolomite aggregate in a sandstone matrix. The conglomerate (and breccia) probably formed in place as explained in the Phase I

report,[1] and may have formed shortly after lithifaction. The conglomerate and breccia and numerous fractural zones contain fragments that are of such an angular nature that they should pose no problems in terms of structural stability of the lock and dam.

49. In cross sections (Plates 8 and 10) taken parallel to the dam, the 4-ft sandstone bed is a near planar bed. However, in two cross sections (Plates 11 and 14) taken perpendicular to the dam, there appears a slight upward bulge in the bed (and probably in the rock above the bed) in an area directly beneath the dam. The release of "locked in" stresses due to the weight of ice during glaciation could have contributed to the bulge. An unloading phenomenon caused by the lessening of pressure on the bed which occurred when the overlying bedrock was removed during excavation for the dam could have contributed to the bulge. The direct cause of the slight bulge is not postulated.

50. Thirty-four joints were found in the 46 borings put down at the lock and dam site during the last 3 drilling programs; all borings were in the head and taintor gate dam sections. The 34 joint dips were plotted on the frequency histogram presented in Reference 1, and a similar histogram was obtained. It is reasonable to say that the more recently observed joints fit into groupings similar to those groupings obtained at other locations over the project site, namely the lock area. Possible wedge-shaped failures involving the joints detected at the lock and dam are described in References 1 and 3.

Possible Weak Zones

51. The major lithologic units, shown in the geologic cross sections, do not contain all the features considered as possible weak zones. For specific weak features (friable sandstone, shale beds, fractured rock, and clay- or shale-filled partings) at a particular location beneath a concrete structure, consult Plates 1 through 7g. The logs of the borings show each weak feature observed during field logging and the detailed laboratory examination of the cores. Design values for the weak zones or seams can be obtained from the tabulation "Recommended

Design Values for Rock." As an example, the geologic cross section in Plate 9 shows that the major lithologic unit directly under the upper land lock wall is dolomite. Looking at Plate 9 under boring L-1-77, no weak seam appears. Looking at the log of borings sheet, Plate 2, one sees that the dolomite directly beneath the concrete contains a shale-filled parting in a thin friable sandstone seam; just below that is a shale seam in the dolomite.

52. A few shale- and clay-filled partings can be traced between some borings. The majority of the partings in the foundation rock can not be traced between borings and therefore are not considered to be, in themselves, continuous under the lock and dam. Borings show that most all sections of the taintor gate dam rest on competent dolomite while other sections rest on or near sandstone or clay- and shale-filled partings. Borings D-12 and D-38 show concrete founded on or near a thin green clay seam (Plates 4 and 5); D-43 (Plate 6) shows concrete founded on a thin green shale seam; and D-63 (Plate 7d) shows concrete founded on a seam of white clayey sandstone. As discussed under Bedrock Stratigraphy, the thin filled partings have less than 100 percent coating on their parting surfaces, and the partings have interlocking asperities. Shearing resistance along this type of parting is much higher than the shearing resistance would be in the filler material itself. These thin filled partings, $< 1/8$ in., would offer more shearing resistance than a shale bed of several inches in thickness.

53. The extremely low strength of the intact shale parallel to its bedding dictates that, for conservative design, any shale bed be treated as a potential sliding plane parallel to its bedding. Boring D-11 (Plate 10) shows a shale bed underlying the concrete in the head gate dam section. It is believed that the same shale bed (approximate el 430 ft) is present behind taintor gate No. 3 and could exist under a portion of the taintor gate dam (see Plate 12). However, the shale bed is within the St. Peter sandstone, which in all borings through the taintor gate dam, has been shown to be missing. It was likely removed during construction at this location also.

54. Borings through the head gate dam reveal an important finding. The first 13 of 30 gate sections were apparently founded on a sandstone ridge. The thickness of the sandstone averages 5.9 ft and ranges in thickness from 3 to 11 ft. The sandstone is moderately friable to friable; it is moderately to weakly cemented with some lenses or layers consisting of loose sand. High core loss was obtained in the sandstone unit. The weakly cemented friable sandstone and loose sand are considered as possible weak zones.

55. The first 3 and 4-1/2 ft of bedrock beneath the lower approach walls in borings GW-1 and GW-2, respectively, is fractured. The fractured rock in these two borings consists of shale, clayey shale, friable sandstone with shale-filled partings, and cherty dolomite (Kress Formation). This fractured zone constitutes a weakness in the bedrock and should be considered in a structural stability analysis. Similar amounts of fracturing in the same type of rock exist under the downstream portion of the landside lock wall (see Plate 2, Reference 2). The bedrock under the upper portion of the landside lock wall and under the riverside lock wall consists of dolomite with shale-filled partings and thin sandstone layers. About 5 ft beneath the base elevation of the lock is the nominal 4-ft-thick sandstone layer that is continuous over the lock and dam site. The lowest value of internal friction (ϕ = 13.7 deg) obtained on a shale-filled parting was measured on a test specimen recovered from this sandstone layer.

56. Another possible weakness in the foundation is the joint system. Reference 1 describes the possibility of individual and conjugate joints forming rock wedges in sections of bedrock where scouring has occurred. Shear strength parameters for natural joints in the sandstone and shale are presented in the Part VIII.

PART V: TEST SPECIMENS AND TEST PROCEDURES

Cores Received

57. Concrete and rock core from 4 and 18 borings, compliance and scour detection studies, respectively, were received at the WES. Pertinent information concerning the core received for the compliance study is presented in Table 2. Similar information is not presented for the core received from the scour drilling operation because none of the core was scheduled for testing. No significantly different materials, i.e., different than obtained during the "Duplicate Locks" and "Phase I Major Rehabilitation" programs,[1,3] were recovered during the compliance or scour detection drilling programs.

Selection of Test Specimens

58. A detailed visual examination of all the core was made for detailed logging purposes and to assist in the selection of representative test specimens of concrete and of the different foundation materials. Concrete test specimens from the deep vertical borings were selected from the top, middle, and bottom of the core. No concrete was tested from the core recovered from the taintor gate apron section.
Test specimen depths shown in the tables of test results represent the mid section of the test specimen; i.e., el 466.1 is the midpoint of a piece of core from el 466.6 to 465.6. Six-inch diameter by twelve-inch long concrete and rock cores were used for testing, the exception being the specimens for direct shear testing. Direct shear specimens were nominal 6-in. diameter and about 6 in. in length.

59. For the characterization property tests (effective (wet) unit weight (γ_m), compressional wave velocity (V_p), and compressive strength (UC)) and the engineering design tests (modulus of elasticity, Poisson's ratio, triaxial and direct shear), an attempt was made to select test specimens to be representative of the rock in close proximity to the base of the structure. The test assignment locations can be obtained from appropriate tables of test results.

60. A weakly cemented sand was recovered from beneath the head gate dam and was tested in direct shear. The sand was obtained from about 4 ft below the base of head gate bay No. 6.

Test Procedures

61. The characterization properties tests and the engineering design properties tests were conducted in accordance with the appropriate test methods tabulated below:

Property	Test Method
Characterization	
Effective Unit Weight (As Received), γ_m	RTM 109*
Dry Unit Weight, γ_d	RTM 109
Water Content, w	RTM 106
Compressional Wave Velocity, V_p	RTM 110 (ASTM D 2845)**
Compressive Strength, UC	RTM 111 (ASTM D 2938)
Engineering Design	
Elastic Modulus, E, and Poisson's Ratio, ν	RTM 201 (ASTM D 2148)
Direct Shear Strength	RTM 203

* Proposed Rock Test Method, Corps of Engineers, in review prior to publication.

PART VI: TEST RESULTS AND ANALYSIS

Characterization Properties

62. The results of the characterization property tests and the engineering design tests are presented in Table 3. The average value, the range and the number of tests for the concrete and the dolomite bedrock are summarized below:

Summary of Characterization Properties

	Effective Unit Weight γm, lb/ft^3	Dry Unit Weight γd, lb/ft^3	Water Content w, %	Comp Wave Velocity Vp, ft/sec	Compressive Strength UC, psi
Concrete					
Average	153.2	145.1	5.6	15,597	6640
Range	6.2	8.6	2.7	2,805	4750
No. of tests	8	8	8	8	8
Dolomite					
Average	160.2	154.4	3.8	15,717	5080
Range	5.6	3.8	2.4	277	5270
No. of tests	3	3	3	3	3

Only one specimen of sandstone was tested and its properties can be found in Table 3. An analysis of the characterization properties will be presented for the concrete and dolomite.

a. Concrete. The unit weights are reasonable and consistent with the unit weights reported in Reference 1 for cores taken from the head gates and tainter gates structures. Previous average values of 153.8 and 151.1 lb/ft^3 for concrete beyond frost-damaged zones compare well with the average of 153.2 lb/ft^3 presented in the above tabulation. The average compressional wave velocity for the previously tested core from vertically drilled holes is 15,088 ft/sec (core from boring L-1) and compares well with the average value of 15,597 ft/sec presented in the above tabulation. The average compressive strength presented above, 6640 psi, compares well with a similar value of 5300 psi for cores from the head gate and tainter gate dam sections as reported in Reference 1. With the exception of the compressive strength values, the range in unit weight, velocities,

and moistures indicates uniformity of the internal concrete at the lock and dam. The range in strength is large but is attributed to two specimens with relatively low strengths (4510 and 3900 psi) obtained from frost-damaged concrete zones. These strengths are considered quite acceptable in terms of the static compressive loading the structures will actually receive.

b. Dolomite. A limited number (3) specimens of dolomite were tested in order to verify that the dolomite beneath the dam sections was similar in unit weight, velocity, and compressive strength to the same rock under the lock and lower approach wall. Characterization properties for dolomite from beneath the lock and lower approach wall are presented in Reference 3. The average unit weight, velocity, and compressive strength from Reference 3 is 164.5 lb/ft^3, 14,140 ft/sec, and 6300 psi; these values compare very well with similar values for dolomite tabulated above. The dolomite bedrock beneath the head gates and taintor gates dam sections is considered to have nearly the same characterization properties as does the dolomite under the lock and lower approach wall.

Modulus of Elasticity and Poisson's Ratio

63. Results of the modulus of elasticity and Poisson's ratio are presented in Table 3. The stress-strain relation for the concrete, sandstone, and dolomite are presented in Plates 18 through 21. The modulus was calculated as an incremental value between 1000 and 2000 psi on the stress-strain curve; in all cases this stress increment corresponds to the linear portion of the stress-strain curve for the concrete and both the sandstone and dolomite. The stress-strain curves for both rocks have a concave upwards initial portion which represents closure of the cracks formed from stress relieving the core and closure of inherent microfractures. Poisson's ratio was calculated at a stress value of 2000 psi.

64. The average modulus for the near surface concrete (to about 2.5-ft depth) and deeper concrete is 1.37×10^6 and 5.44×10^6 psi, respectively; Poisson's ratio is 0.15 and 0.21, respectively. Both the modulus and Poisson's ratio compare well with similarly located concrete specimens tested and reported in Reference 1. The average modulus and Poisson's ratio for the sandstone and dolomite is 2.10×10^6 psi, 0.26

and 3.97 x 10^6 psi, 0.15, respectively. The value for sandstone (moderately hard) is in good agreement with the previously reported moduli and Poisson's ratio.[1] The current modulus value for the dolomite is about twice as great as the previously reported value.[1] The dolomite specimens tested during this study were not as vuggy as those previously tested, which could account for some of the difference in moduli.

Peak and Ultimate Shear Strength

65. The Duplicate Locks[3] and the Phase I Major Rehabilitation[1] reports contain direct shear test results that define the shear strength parameters for the rock types and different rock conditions found at the Starved Rock Lock and Dam. These values are presented in Part VIII of this report.

66. A new material, one that was not recovered and tested in previous drilling operation, was recovered from a depth of 4 ft below the base of head gate bay No. 6 in boring D-67. The new material was a weakly cemented sand.

67. The sample was classified as a silty sand (SM). A direct shear box (1 by 3 by 3 in.), used for testing soils, was used to run direct shear tests on the sand. The normal loads used were 2, 4, and 8 tsf. A plot of the normal load versus shearing load is presented in Plate 22. The angle of friction for the sand is 27 deg with a cohesion is 0.22 tsf.

68. Almost all of the clay seams found in the core were in or adjacent to zones of fractured dolomite or friable sandstone. Specimens from these zones could not be obtained for shear testing. Attempts were made in the field to recover testable specimens, but with very little success. One specimen of competent sandstone from D-75 was received intact. The specimen contained a sandy clay parting 1/8 in. in thickness at its thickest point. The parting surfaces had interlocking asperities about 1/2 in. from peak to valley, and the filler covered about 60 percent of the parting surfaces. The asperities were semirounded. The asperity configuration was typical of the majority of clay partings observed in the core.

69. The specimen was tested using the multistage loading technique because other specimens were not available. The normal load versus shear load is presented in Plate 23. The peak shear strength value of phi (ϕ) is 57.9 deg and cohesion (c) is 2.5 tsf. The ϕ of 57.9 deg is a reasonable value when it is compared to the lowest peak phi obtained for the intact competent sandstone (51.7 deg); see Part VII under "Recommended Design Values for Rock." The relatively thin sandy clay filler apparently did not affect the shear strength of the discontinuity.

70. Examination of the specimen after testing revealed that the asperities were not sheared off at their bases; instead, a small amount of the peaks were ground away. Higher normal loads than used would be required to shear the asperities along their bases. A residual value could not be obtained using the low range of normal loads of 2 to 8 tsf. The 2- to 8-tsf normal load range was used because it adequately covers anticipated field loads. Plate 23 presents the residual shear strength obtained from direct shear tests conducted on precut competent sandstone samples.[1] The precut failure envelope is presented for comparison.

71. There were no clay-filled partings in the dolomite available for testing as mentioned earlier. Clay material was removed from a number of the broken filled parting surfaces. The material was classified as sandy clay (CL) with a maximum plastic index (PI) of 28, a liquid limit (LL) of 48, and a plastic limit of 20. A correlation between the Atterberg limits of the CL material and shear strength was made using ETL 1110-1-58, dated 17 February 1972.[10] It is recognized that correlations of this type should not be considered complete substitutes for shear testing.

72. The vast majority of the thin (<1/8 in. thick) filled partings have interlocking asperities as described under "Bedrock Stratigraphy." However, for the few relatively smooth clay-filled partings (<1/8 in. thick and asperities of low relief and long period), an attempt is made to approach a reasonable lower bound shear strength. Figure 4 is taken from the ETL. For a PI of 28, the ϕ range of all values plotted is 20

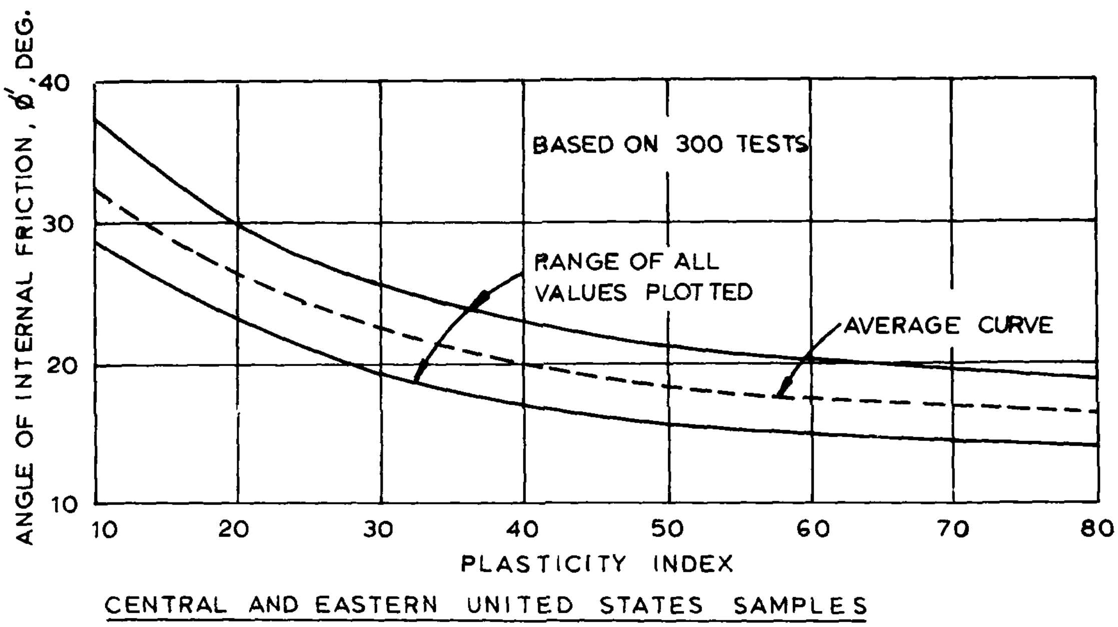


Figure 4. Correlation between ϕ' and plasticity index, from ETL 1110-1-58

to 26.5 deg. This range of phi values could be used in a stability analysis where relatively smooth clay-filled partings in the dolomite are considered.

73. Because the vast majority of the clay-filled partings observed at the lock and dam have interlocking surfaces, it is expected that the shearing resistance along a parting would be much greater than the shearing reistance through the filler itself. However, a very conservative estimate of the shearing resistance would be obtained if a ϕ = 20 deg and c = 0 (from Figure 4) were considered for clay-filled partings.

74. The shear test data for shale-filled partings in dolomite is presented in Figure 5. The data presented in this figure was obtained from a number of the previous WES drilling and testing programs at Starved Rock Lock and Dam. Both repetitive loading and direct shear test results are plotted. Almost all the test results are from repetitive tests. It was necessary to conduct repetitive tests because during the different drilling and testing programs only a few shale-filled partings were obtained at a time. Shear stress versus shear and normal deformation curves are presented in Plates 24 through 32 for the repetitive tests. The shear stress versus shear deformation curves for the direct shear tests are presented in Plates 33 through 35.

75. In the repetitive tests the specimen is initially sheared until failure is obtained. The shear and normal load is released, and the shear block repositioned and resheared under an increased normal load. Repetitive testing can be useful; however, the test results are difficult to interpret, since after initial shearing the discontinuity surface undergoes irreversible changes that affect the shear strength values from succeeding tests. The failure envelopes obtained from repetitive testing will usually define strengths intermediate between the maximum and residual strength. In general, repetitive testing will yield a conservative estimate of the maximum shear strength. It is recognized that repetitive testing may be used to measure the residual shear strength. Continued displacement ultimately reduces the strength available along the discontinuity to its residual shear strength. After a number of shearing cycles, the maximum stress is, in fact, the residual stress.

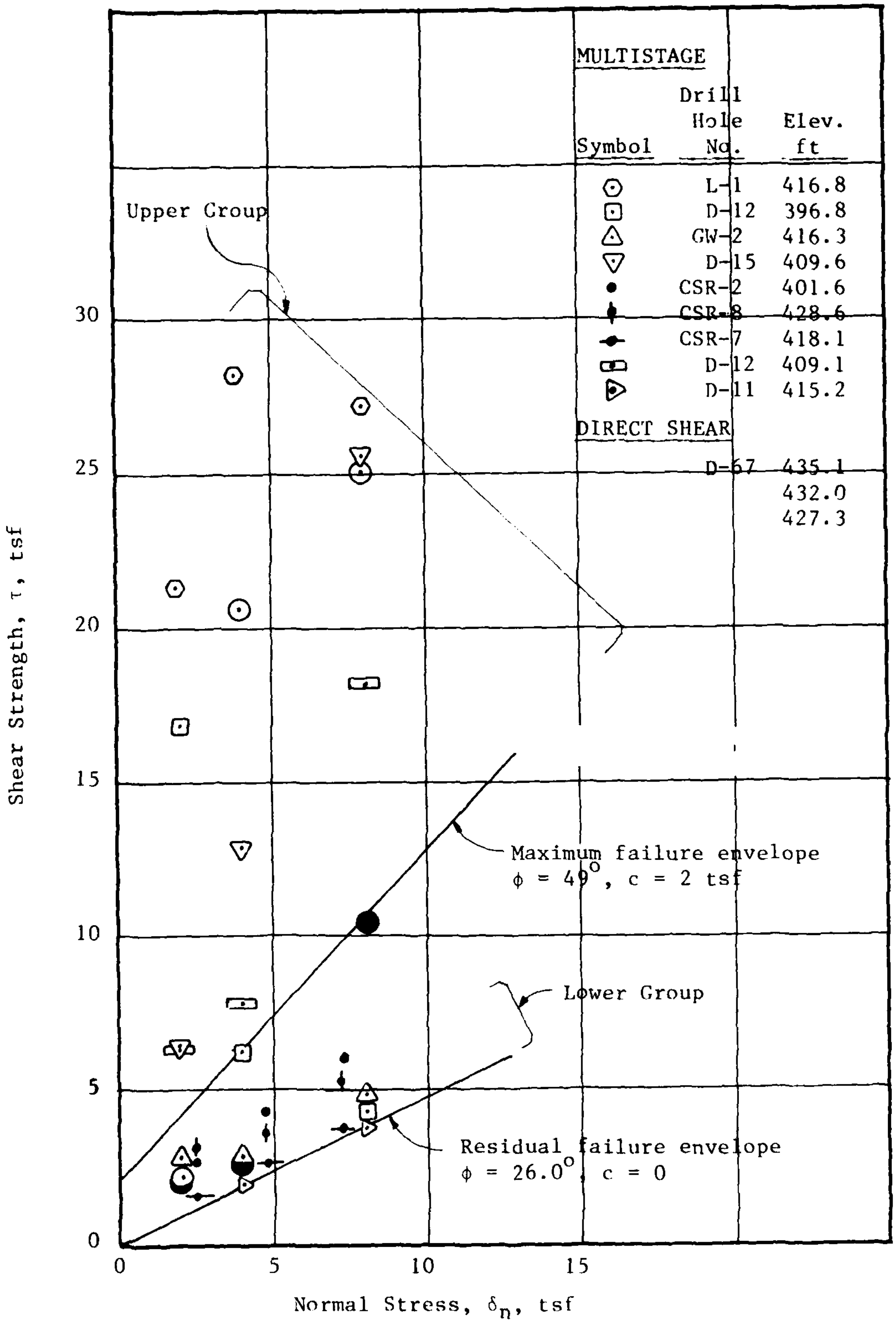


Figure 5. Direct shear results, shale-filled parting in dolomite, Starved Rock Lock and Dam

76. In Figure 5 the lower grouping of repetitive test results represent the residual shear strength (ϕ_r) for shale-filled partings in dolomite; the ϕ_r = 26 deg and c = 0. A series of direct shear tests was conducted, and the peak and residual stress values are represented in Figure 5 by the open and solid circles. The residual stress values were obtained by repositioning the shear blocks after the initial shear was recorded, reapplying the same normal stress, and reshearing the specimens. Each specimen was resheared from two to four times. The residual shear stress obtained from the specimens tested at 2- and 4-tsf normal load plot well within the lower group of repetitive test results. The residual stress value obtained from the specimen tested in direct shear at δ_n = 8 tsf is outside the lower group. However, this is not surprising considering the different specimens available for testing.

77. The shale-filled parting surfaces varied in roughness; asperity height was from <1/16 in. to 1/2 in. and had periods of one to several inches. The filler thickness varied from a film coating to >1/2 in. In addition, the parting surfaces varied in the amount of area that the filler coated. Some partings had 60 percent of their surfaces coated while others had varying coverage up to 100 percent. The test specimens in the lower group generally had relatively smooth parting surfaces and uniform filler thickness.

78. In Figure 5 the upper group of test data shows considerably more scatter than the lower group. Examination of the specimen partings from this group revealed that the parting surfaces were rougher and that the filler was thinner than specimen partings from the lower group. Because of the scatter and the lack of test data at >8-tsf normal load, a conservative failure envelope was fitted through the lowest data point in the upper group. A ϕ = 49 deg and a c = 2 tsf are conservative maximum shear strength values for the shale-filled partings in dolomite.

79. No samples of the friable sandstone were obtained for cross-bed shear testing. Intact specimens were tested parallel to bedding and shear strength parameters are presented in the tabulation of "Recommended Design Values for Rock." Because of the relative homogeneity of the friable sandstone, it is believed that cross-bed shear strengths would

approach the intact shear strengths. The intact shear strengths are recommended to be used in place of cross-bed shear strengths.

PART VII: CONCRETE CONDITION

Concrete from Compliance Borings

80. The concrete core recovered from boring L-1 was tested during the Phase I Rehabilitation program. Results of tests conducted on the core can be found in Table 6 of Reference 1. The concrete core recovered from the four compliance borings (L-1, D-11, D-12, and D-13) is in very much the same condition as the concrete core recovered during the Phase I drilling program. See pages 29 through 31 in Reference 1 for a general description. Boring L-1 was drilled in the land lock wall (monolith 11) and the core revealed that the top 0.6 ft of concrete was new. The new concrete had been placed as an overlay during a previous resurfacing of the top of the lock walls. The remaining 42.9 ft of concrete is considered structurally sound and should serve its original intended purpose. The interface between the concrete and a thin friable sandstone seam is poorly bonded. The concrete core recovered from D-11 in pier 14 of the head gate section was new in the top 0.9 ft, again the result of an overlay of new concrete. The remaining concrete appears sound except for local honeycombing at about 6 and 12 ft up from the base of the pier. These two areas are 0.2 and 0.5 ft thick, respectively; concrete aggregates with little or no cement were recovered from these two zones.

81. The concrete core from boring D-12, which was drilled through the 56.2-ft height of taintor gate pier 6, was moderately deteriorated to 0.3-ft depth. The boring was put through the central section (through the wooden walkway atop the taintor gate dam section). The remaining concrete appears sound with three natural cracks that caused separation of the concrete within 4.6 ft of the top of the pier. A construction joint at el 453.7 (19-ft depth) is stained and contains a small amount of cracking to a depth of 0.1 ft; the joint was a "cold joint." Upper pool el is 459, so that water from the upstream pool could have access to the construction joint causing the staining. The cause of the cracking is not postulated. The concrete-bedrock contact was tight with the

concrete resting on dolomite at el 416.5 ft. The concrete core in D-13 is sound throughout the 31.1 ft depth. The contact is tight with dolomite present as the bedrock material. See Reference 1 for a description of the surface concrete in the lock, head gates, and taintor gate structures.

Concrete from Instrumentation Borings

82. During the drilling operation for the abutment instrumentation study, two vertical borings were drilled in each of taintor gate piers 10 and 11. These two piers were referred to as piers 2 and 1, respectively, in Reference 1. Two borings were located 6.5 ft in from the upstream side and on the piers' centerline. Two were located on centerline and at 6 ft and 9 ft in from the downstream vertical face of piers 10 and 11, respectively. The concrete core from the upstream boring in pier 10 (borings SR WES D-58-78) is severely deteriorated to a depth of 4.0 ft. From 0 to 2.5 ft only concrete aggregate and a few pieces of matrix were recovered. The core from 2.5 to 4.0 ft is cracked. Evidence of frost damage is present at a depth of 5 ft. Prior to drilling D-58 the deepest frost-damaged concrete in the taintor gate piers was found in piers 3 and 6 (pier 3 is referred to as pier 9 in Reference 1); it was 3.1 ft deep in each pier and was located near the nose of the piers. Boring D-59, located near the downstream face of pier 10, contained obviously frost-damaged concrete to a depth of 3.5 ft. The concrete from 3.5 to 5 ft has numerous natural breaks that are slightly weathered; these breaks could be the result of deeper freezing and thawing action. The core from both borings showed evidence of alkali-silica reaction just beneath the frost-damaged zones and minor amounts near the bottom of the core. Serious alkali-silica reaction is reported in Reference 1 for concrete in the head gate and taintor gate sections of the dam.

83. Concrete core from the two vertical borings in pier 11 (D-56 and D-57, located upstream and downstream, respectively) showed frost damage to depths of 2 ft with small amounts of alkali-silica reaction

products present just below the damaged zones. The core appears sound below these zones. The concrete core indicates that the bases of piers 10 and 11 rest on dolomite. Core from the two borings in pier 10 show competent dolomite beneath the base of the pier. Core from the two borings in pier 11 show shattered dolomite from 0.1 to 0.3 ft below the base of the pier. The shattered rock is possibly due to blasting during excavation for the dam. The shattered rock could have resulted in settlement or tilting of pier 11 and contributed to jamming the connected taintor gate. The taintor gate is supported between piers 10 and 11 and the gate has been difficult to operate for a number of years. The concrete from pier 11 did not show unusual signs of distress. The three horizontal borings through pier 11 show frost damage to an average depth of 1.7 ft. The previous study showed frost damage at an average depth of 1.4 ft in a number of other taintor gate piers.[1]

Base Elevation Revealed in Borings

84. The following tabulation is presented to summarize the actual base elevations of the lock and dam structures as revealed in borings. The tabulation indicates the different elevations to which some sections of the structures were taken, in some cases quite a bit below the base elevations shown on working drawings. Local bedrock conditions during construction probably dictated additional excavation.

Structure	Boring No.	Boring Location	Working Drawing Base Elevation of Concrete	Actual Base Elevation of Concrete
Lower Approach Wall	SR WES GW-1-77		430.0	428.1
Lower Approach Wall	SR WES GW-2-77		430.0	431.5
Lock	SR WES L-1-77	Land wall, Monolith 11	421.0	415.5
Fixed Dam	SR WES D-13-77	Center	438.0	432.9
Head Gates	SR WES D-11-77	Pier 17	435.0	427.8

Structure	Boring No.	Boring Location	Working Drawing Base Elevation of Concrete	Actual Base Elevation of Concrete
Head Gates	SR WES D-60-79	Bay 7	435.0	439.7
Head Gates	SR WES D-61-79	Bay 21	435.0	427.2
Head Gates	SR WES D-66-79	Bay 8	435.0	439.8
Head Gates	SR WES D-67-79	Bay 6	435.0	440.3
Head Gates	SR WES D-68-79	Bay 2	435.0	439.9
Head Gates	SR WES D-69-79	Bay 11	435.0	439.2
Head Gates	SR WES D-70-79	Bay 14	435.0	434.0
Head Gates	SR WES D-71-79	Pier 11	440.0	435.5
Head Gates	SR WES D-72-79	Pier 11	435.0	438.0
Head Gates	SR WES D-73-79	Pier 4	440.0	434.5
Head Gates	SR WES D-74-79	Pier 4	435.0	438.5
Ice Chute	SR WES D-64-79	Apron	430.0	419.5
Taintor Gate	SR WES D-62-79	Bay 1	426.0	419.5
Taintor Gate	SR WES D-63-79	Bay 4	426.0	417.0
Taintor Gate	SR WES D-65-79	Bay 2	429.2	419.6
Taintor Gate Pier	SR WES D-12-77	Pier No. 6, Center	426.0	416.5
Taintor Gate Pier	SR WES D-56-78	Pier No. 11, U/S	426.0	416.7
Taintor Gate Pier	SR WES D-57-78	Pier No. 11, D/S	426.0	419.6
Taintor Gate Pier	SR WES D-58-78	Pier No. 10, U/S	426.0	417.0
Taintor Gate Pier	SR WES D-59-78	Pier No. 10, D/S	426.0	422.7
Taintor Gate Bay No. 5	SR WES D-38-78	Apron	426.0	420.1
Taintor Gate Bay No. 8	SR WES D-41-78	Apron	426.0	415.3
Taintor Gate Bay No. 7	SR WES D-42-78	Overflow Section	426.0	416.5
Taintor Gate Bay No. 8	SR WES D-43-78	Apron	426.0	418.9
Taintor Gate Bay No. 9	SR WES D-48-78	Apron	426.0	418.9

Figure 6 shows the scouring at the face of the apron in the taintor gate dam as plotted by NCC. Superimposed on this graph are the actual base elevations of concrete at boring locations given in the above tabulation. Figures 7, 8, and 9 show the scouring at the apron face in the head gate dam. These figures illustrate the base elevation of the concrete as

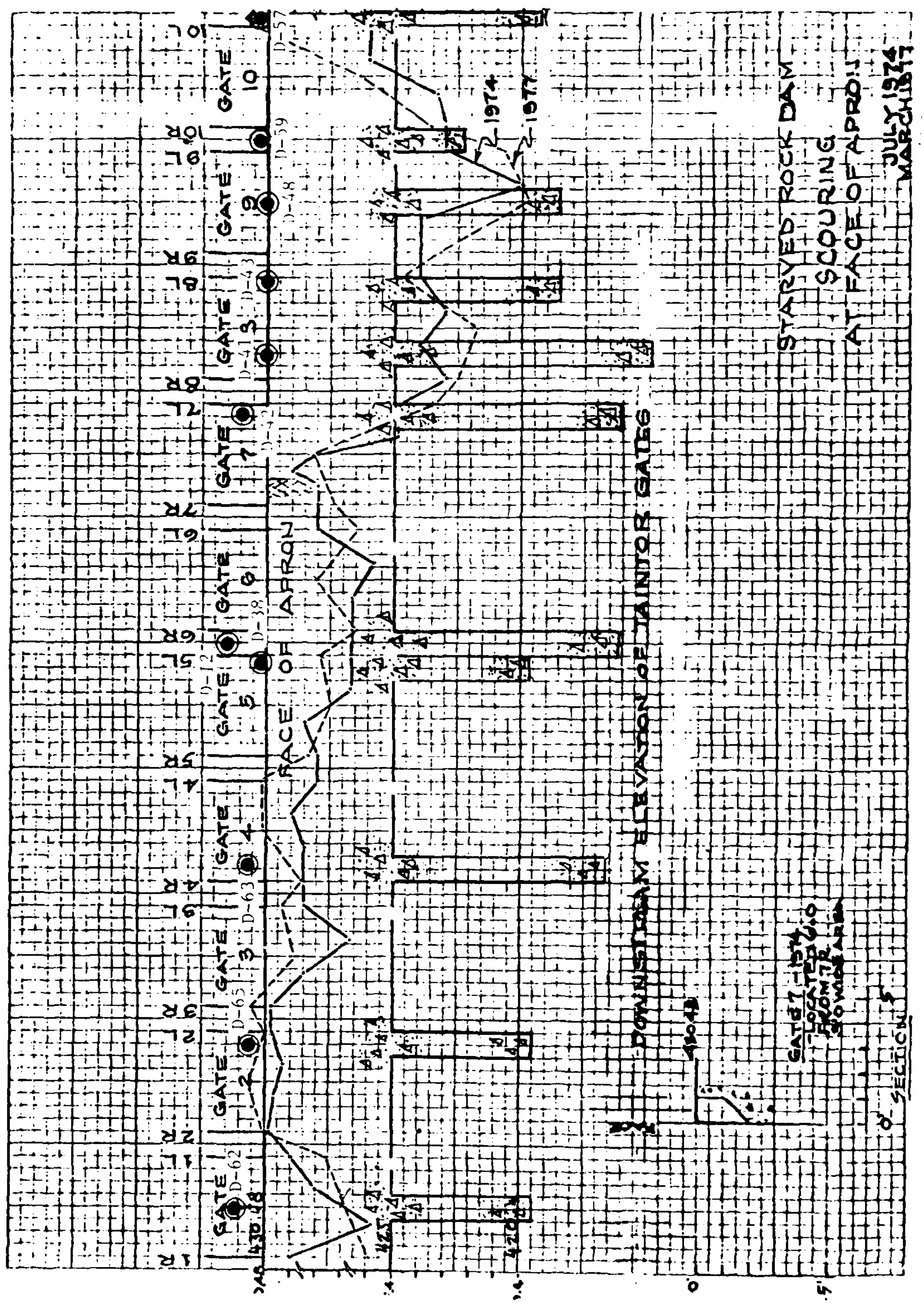
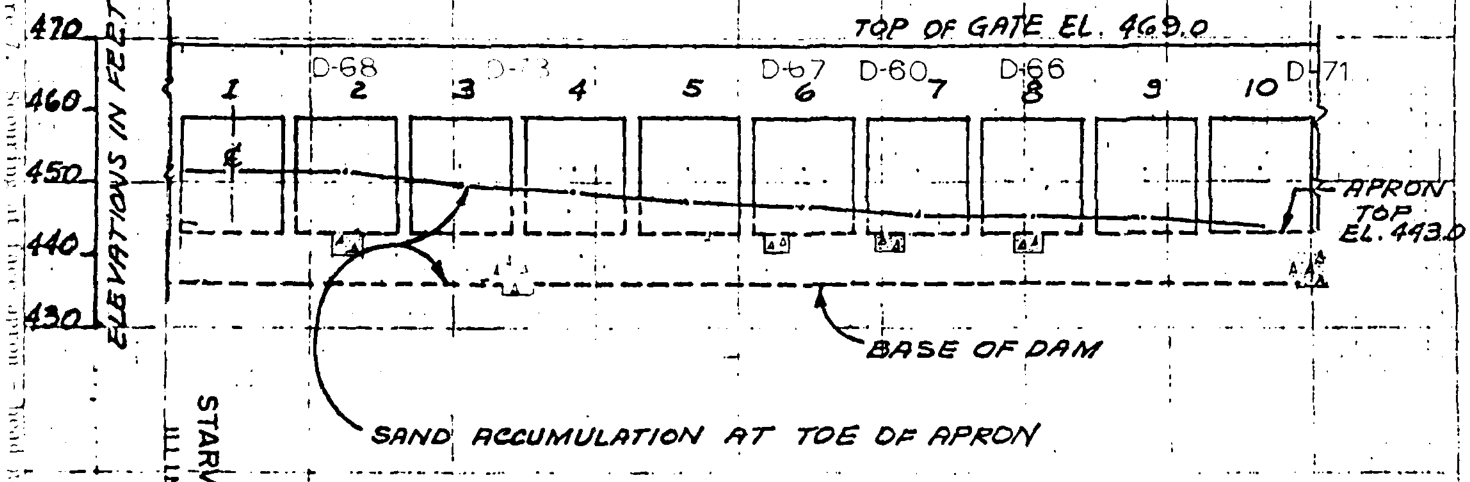


Figure 6. Scouring at face of apron

GENERAL NOTES:

1. GROUND ELEVATION BASED ON SURVEY OF JUNE, 1977.
2. FOR GATES 1 THROUGH 14, BECAUSE OF HIGH GROUND DOWNSTREAM OF THE DAM, GROUND ELEVATIONS ONLY AT THE TOE OF THE APRON WERE SURVEYED. FOR GATES 15 THROUGH 30, AND THE ICE CHUTE, WHERE THE GROUND IS LOWER, CROSS-SECTIONS WERE TAKEN DOWNSTREAM OF THE DAM.



STARVED ROCK DAM
ILLINOIS WATERWAY

DOWNSTREAM ELEVATION - HEADGATES SECTION OF DAM

SCALE: HORIZ. & VERT. 1" = 20'-0"

Figure 7. Scouring at face apron - head gates 1-10

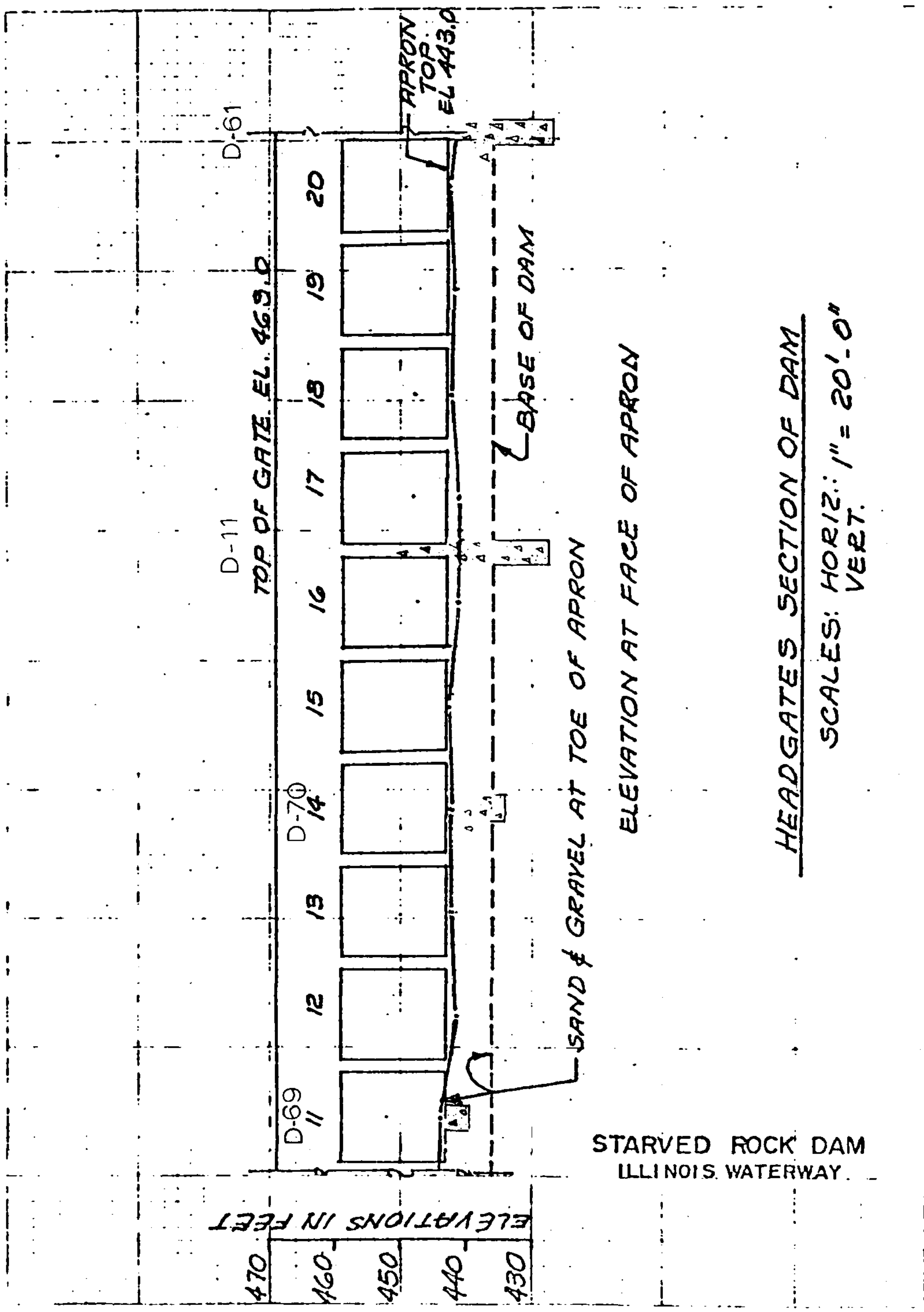


Figure 8. Scouring at face apron - head gates 11-20

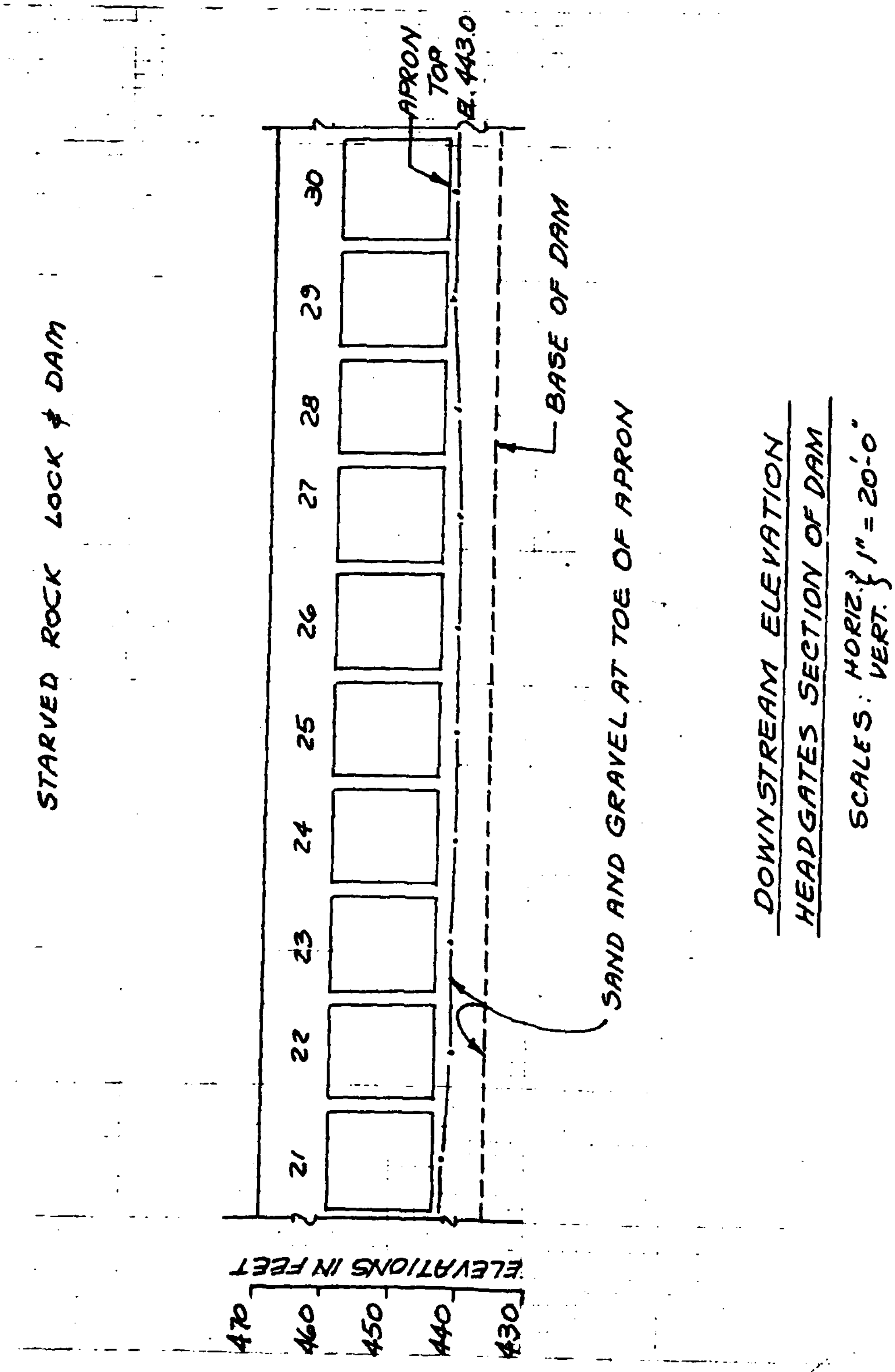


Figure 9. Scouring at face apron - head gates 21-30

revealed in borings. Indications are that the 1977 scouring has not undercut the apron for the full length of the two dam sections. The base elevation of the taintor gate dam section is variable, and extrapolation of these actual base elevations to other sections of the taintor gate should be done with caution. The head gate dam appears to have been built using two different design criteria. The first 16 gate bays are founded on weakly cemented and friable sandstone, the 17th pier founded on a shale seam, while the remaining gate bays appear to be founded on competent dolomite. Because of the variable foundation elevations in the head gate dam section, extrapolation of foundation elevations to other sections of the head gates, notably bays 17 through 30, could be misleading. It is suggested that an NX boring be put through the bays already not drilled to determine actual base elevations. A figure for the ice chute is not presented. The one boring in the ice chute overflow section shows the base of concrete at el 419.5 ft; working drawings indicate the base of this structure to be el 430.0 ft.

PART VIII: SUMMARY OF FOUNDATION CONDITION, CONCRETE AND RECOMMENDED DESIGN VALUES

Scour Detection

85. Inquiries were made into the possibility that riprap or armor stone had been placed in scoured areas behind the taintor and head gate dams. To our knowledge this has not been done at Starved Rock Lock and Dam.

86. A total of 17 borings were drilled behind the dam. No evidence of displaced or recently (post-dam construction) disoriented rock was found during the drilling of the scour drilling. The top 4 ft of bedrock consists of friable sandstone or hard dolomite and moderately hard sandstone. The top of rock is highly irregular. Loose material to 4-ft depths including sand, sandstone, dolomite, concrete, and metamorphic rock was found within 130 ft of the left dam abutment; local bedrock and river deposits account for the loose materials. The scour data (top of rock) did not agree with 1977 scour profiles compiled by the Chicago District.

87. Eight borings (five for scour and three for compliance) were carried through the concrete apron and overflow sections. The contact between concrete and bedrock was tight, and the concrete was founded on dolomite; thin shale- and clay-filled partings are at or near the contact in two of the five borings. No undercutting of the apron was detected in the borings. The eight borings through the apron and overflow section show the concrete to be from 10.7 to 14.3 ft thick; minimum apron thickness on working drawings is 5 ft.

88. During Phase I a 1-ft thick clay seam or lens was found in D-14-77 at el 411, 4 ft D/S of pier No. 8. Borings D-41 and D-42 through the apron and overflow section on either side of pier 8 showed no trace of the clay. The clay remaining D/S is a portion of a clay lens that was apparently removed during construction, or is just a small lens.

Foundation Condition

Backfill

89. The backfill behind the land lock wall and lower approach wall is probably spoil from the lock and dam excavations. A mixture of sand, clay, gravel, and boulders, the same as local bedrock, was recovered in borings during the Phase I[1] and Structural Stability[2] exploration. The material did not appear to be stratified.

Bedrock stratigraphy

90. The Ordovician St. Peter sandstone and the Shakopee dolomite were the two strata encountered at the lock and dam site. The Tonti and Kress sandstones represent the St. Peter sandstone formation. The Tonti member is a medium- to fine-grained, well sorted, noncalcareous, friable sandstone. The Kress is a coarse rubble or conglomerate of angular chert sometimes in a matrix of green shale, sand, or clay. One-foot thick shale layers were found in the Kress.

91. The Shakopee dolomite formation is light brown to light gray, fine-grained, argillaceous to pure and occurs in thin to medium beds. It contains lenses and layers of sandstone up to 4 ft thick, shale seams up to 0.3 ft thick, and shale- and clay-filled bedding planes throughout. Algal reefs up to 1 ft thick are found in the Shakopee.

92. A major unconformity separates the St. Peter and the Shakopee in the Starved Rock area. An interval of erosion and nondeposition created the irregular erosional surface that separates these two bodies of bedrock. This irregular surface explains some of the differences in elevation of the contact between the St. Peter and the Shakopee.

Geologic cross sections

93. Nine cross sections were drawn; one along the lock land wall and the lower approach wall, two along the dam, and six perpendicular to the dam structures. The sections clearly indicate the unconformable contact between the St. Peter and Shakopee formations. The sections delineates the 4-ft sandstone bed within the Shakopee; the bed is continous under the lock and dam. Reefs, fault zones, solution channels, and occasional discontinuous seams and lenses of clay, shale, sandstone,

dolomite and chert can be traced between some borings. Log of boring sheets give the location of each of these and additional similar features observed in the core.

94. In addition to the 4-ft sandstone bed, four other features observable in the sections may be continuous over the lock and dam site. They are the small displacement fault zone in the Kress sandstone, solution cavities in the Shakopee, conglomerate and breccia found above the 4-ft sandstone bed, the shale bed found within the Kress sandstone. No clay seams were traceable across the lock and dam site.

Bedrock structural characteristics

95. Local bedding dips from <1 to 12 deg at the formational contact, while in the 4-ft sandstone below this contact a 1-deg dip exists. The St. Peter/Shakopee contact marks a major unconformity which is an irregular erosional surface caused by solution weathering.

96. The Sandwich Fault Zone, 26 miles to the northeast, is the only major regional structure. No major faulting was observed in the recovered bedrock core. Small displacement (<1.6 ft) faulting and slickensides occur frequently in the core. A zone of small faults exists in Kress sandstone within el 420 to 425. This faulted zone was not seen in core recovered from beneath the dam sections. The faults detected in the foundation are considered not to be a problem in terms of structural stability.

97. A total of 22 borings were put through the concrete dam sections. The Kress, mostly friable, coarse rubble or conglomerate in a matrix of shale, sand, or clay, was apparently removed prior to constructing the taintor gate dam section. The Tonti, almost pure, friable sandstone, was found directly under at least the first 16 of the 30 head gate bays. The 12 borings in the taintor gate dam showed the base of the concrete to be founded on competent dolomite. However, in some of the core shale- and clay-filled partings and clay seams were present at or near the concrete/bedrock contact. The dolomite is dense to porous in nature. It contains vuggy areas and in a few locations has developed solution cavities up to 0.4-ft deep. The porous nature of the dolomite should not cause problems in terms of the dam stability.

98. There appears to be a slight upward bulge in the 4-ft sandstone bed (and probably in the rock above the bed) in an area directly beneath the dam. This is seen in the cross sections perpendicular to the taintor gate dam section. The bulge could be due to a type of unloading phenomenon caused when the overlying materials were removed during excavation for the dam. The release of "locked in" stresses due to the weight of ice during glaciation could also have contributed to the bulge.

99. The joints observed during the compliance and scour programs are considered to be within the same joint sets reported previously.[1,3] Reference 1 discusses the possibility of joints participating in local failures of the approach and lock walls and of the dam:

> Individual joints could provide an inclined surface on which a horizontal shear failure could daylight. And if the orientation of joint sets form possible rock wedges, then sliding along the joint surfaces could occur. One potential sliding mass is a wedge bound on the top by concrete, exposed face due to scouring and two intersecting cross-bed joints. The formation of potential wedges is illustrated in Figure 5 of Reference 3.

Examples of possible slide wedges are presented in Reference 1. Figure 6 indicates that the face of the taintor gates apron is not undercut when the base elevations, as indicated in borings, are considered. It would be undercut at gate bays 7, 8, 9, and 10 if the base elevation was as shown on the working drawings. The occurrence of slide wedges at the taintor gate dam is less likely because scouring is not as severe as once thought.

Lower approach wall,
<u>landside lock wall</u>

100. Possible weak zones under the lower approach wall and the downstream portion of the landside lock wall are the fractured and the intact rock containing friable sandstone with shale-filled partings, and shale. The bedrock under the upper portion of the landside lock wall and under the riverside lock wall is dolomite containing shale-filled partings and thin friable sandstone layers.

101. The recommended design values for the fractured rock zones are ϕ_r = 19 deg, c = 0.5 tsf. The precut shear strength for shale is given for this zone, as it is the prominent rock type in the fractured zone. The recommended design value for the friable sandstone within the intact rock (dolomite) is ϕ = 27.1 deg and c = 5.9 tsf. For the shale-filled partings in dolomite, the recommended design values are ϕ_r = 26 deg and c = 0. For the portions of the walls where a shale unit is considered in the stability analysis, a ϕ = 11.9 deg and c = 3.7 tsf is recommended to be used.

102. The fixed dam was apparently founded on dolomite that contains shale-filled partings that are considered possible weak zones. One boring through the head gate dam shows the concrete base resting on a shale seam about 0.6 ft thick with dolomite beneath. Because of the low strength of the intact shale parallel to its bedding, for conservative design, any shale bed should be treated as a potential sliding plane parallel to its bedding. The shear strength values for the shale are ϕ = 11.9 deg and c = 3.7 tsf.

103. One possible weak zone beneath the head gate dam is the weakly cemented silty sand found directly below the concrete in bays 1 through 13. The shear strength values for the silty sand are ϕ = 27 deg and c = 0.22 tsf. A second possible weak zone is the shale seam found directly beneath pier 16. A ϕ = 11.9 deg and c = 3.7 tsf is recommended when this zone is considered in the stability analysis.

104. The taintor gate dam appears to be founded on competent dolomite. The dolomite contains thin shale and clay-filled partings, and friable sandstone layers. The thin (<1/8 in.) shale and clay-filled partings generally have less than 100 percent coating on their parting surfaces, and the partings have interlocking asperities. Shearing resistance along these types of partings is higher than the shearing resistance along a thicker section of filler material itself. The shale and clay-filled partings in the foundation are not continuous under the lock and dam; i.e., continuous in the sense that a large-scale failure might occur along them. The partings occur frequently and randomly throughout the foundation. A ϕ_r = 26 deg and c = 0 and a ϕ = 29 deg

and c = 0 for shale and clay-filled partings, respectively, are recommended for the stability analysis when these fractures are considered.

105. Neither the scour nor the instrumentation borings revealed any weak bedrock layer that is believed to extend under the bluff that serves as the left dam abutment. Such a feature might have something to do with taintor gate 10 being extremely hard to operate. One feature found in the bedrock that may have influenced the gate is the upward bulge of the bedrock directly beneath and parallel to the dam. The bulge is thought to be due to rebound when the overburden was removed during excavation for the dam; also, locked-in stresses (caused during glaciation) could have been released at this time. The upward thrust of the bedrock near the bluff might have been restrained by the bluff. After completion of the dam, the restraining forces of the bluff could have been relieved somewhat, thus allowing further upward bedrock movement. The movement could have caused, in part, the gate becoming hard to operate. The ongoing instrumentation program is designed to study any movement in the foundation as well as in the bluff. No data is available from the program at this time. Reference 1 outlines the instrumentation program currently underway at Starved Rock Dam.

Concrete Condition

106. In general the condition of the concrete core recovered during the compliance and scour detection drilling is the same as reported in Reference 1. Boring L-1 in monolith 11, landside lock wall, revealed 0.6 ft of air-entrained concrete, the result of recent resurfacing. The remaining 42.9 ft is structurally sound and should serve its original intended purpose. The top 0.9 ft of concrete in D-11 (head gate dam) is new and is the result of recent resurfacing. The remaining concrete is sound with small areas of honeycombing near the base. Such small areas of honeycombing should not affect the structural integrity of the dam. The top 0.3 ft of concrete in the central section of taintor gate pier 6 is deteriorated due to freezing and thawing action; the remaining concrete in the central core of the pier appears sound with small amounts of

cracking and staining occurring on and near a construction joint. The entire length of core from the fixed dam is sound. Reference 1 gives details on the condition of the exposed and the near surface concrete over the lock and dam.

107. Taintor gate piers 10 and 11 were drilled during the instrumentation program for the left dam abutment. The average depth of deteriorated concrete in the top of the D/S and U/S portions of pier 10 is 4.3 ft. Evidence of frost damage was found at a depth of 5 ft. Core from the two borings in pier 10 shows evidence of alkali-silica reaction beneath the frost-damaged zones. Similar occurrences of alkali-silica reaction are reported in Reference 1 for core from the head gate and taintor gate dams. The average depth of deteriorated concrete in the top of the D/S and U/S portions of pier 11 is 2 ft. Small amounts of alkali-silica reaction products were found in the core just below the damaged zones. The concrete below these damaged zones and in the central sections of piers 10 and 11 is structurally sound. Three horizontal borings in pier 11 showed frost-damaged concrete to an average depth of 1.7 ft.

108. Of the 30 vertical borings through concrete in the lower approach wall, lock, and dam, 22 borings showed the founding elevation to be below that shown on the working drawings. Ten borings in the taintor gate dam section show the concrete to be an average 7.8 ft below the base elevation shown on the working drawings. Consult the log of boring sheets for actual elevations at specific boring locations. Removal of weak bedrock is the likely reason for the deeper founding elevations.

Recommended Design Values for Rock

109. Design should consider rock and sand type and the various bedrock structural characteristics described herein. Guidance is presented in the following tabulation as to proper choice of design parameters. The tabulation is taken from Reference 3 and was updated with values obtained during the more recent studies:

	Dolomite	Friable Sandstone	Competent Sandstone	Shale
Characterization Properties				
Effective Unit Weight, lb/ft^3	157.0	127.7	138.3	110.4
Wet Unit Weight, lb/ft^3	162.0*	140.2	147.7	129.9
Compressive Strength, psi	4870	540	4440	--
Tensile Strength, psi	110	75	175	
Shear Strength				
Intact	c=90 tsf $\phi=56^o$	c=5.9 tsf $\phi=27.1^o$	c=0.9 tsf* $\phi=51.7^o$	c=3.7 tsf* $\phi=11.9^o$
Natural Joint	--	--	c=1.45 tsf $\phi=30.5^o$	c=0 $\phi=38^o$
Shale-Filled Parting	c=0 $\phi_r=26^o$	c=0.1 tsf $\phi_r=35^o$	c=1.8 tsf* $\phi_r=26.2^o$	--
Precut, Rock-on-Rock	c=0.0 $\phi_r=31^o$	c=0.0 $\phi_r=33.5^o$	c=0.0 $\phi_r=31^o$	c=0.5 tsf $\phi_r=19^o$
Concrete on Rock	c=1.6 tsf $\phi=63^o$	--	c=0.2 tsf $\phi=73.9^o$	--
Cross-Bed	c=22.2 tsf $\phi=73.1$	c=1.1 tsf** $\phi=38^o$	--	--
Modulus of Elasticity x 10^6 psi	1.82	--	2.00	--
Poisson's Ratio	0.13	--	0.12*	--
Shear Modulus x 10^6 psi	0.65	--		--

Silty Sand (SM) c = 0.22 tsf, $\phi = 27^o$

tsf, tons (force)/square foot

* Newer lower value obtained during the Phase I investigation.

** Values presented in Reference 2.

Recommendations

110. It is recommended that at least five NX borings be drilled through head gate bays 17 through 30 to determine base elevations.

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Table 1

Boring, Locations, Elevations, and Starting Date of Boring

Boring No.	Type of Boring	Location	El. Top of Boring, ft	El. Top of Rock, ft	El. Bottom of Boring, ft	Start Date
SACSR-1	▲	Backfill, lock	464.2	442.1	400.5	14 Aug 71
SACSR-2	▲	Backfill, lock	464.2	436.3	409.3	18 Aug 71
SACSR-3	▲	Backfill, lock	463.5	424.2	399.5	10 Aug 71
SACSR-4	▲	Backfill, lock	464.3	438.5	394.0	6 Aug 71
SACSR-5	▲	Backfill, lock	438.9	438.9	408.9	8 Nov 71
SACSR-6	▲	Backfill, lock	438.7	438.7	423.3	15 Dec 71
SACSR-7	▲	Backfill, lock	464.0	--	441.0	12 Jan 72
CSR-1	⊙	Grounds, Landside Lock	455.5	443.1	380.5	--
CSR-2	⊙	Grounds, Landside Lock	455.7	444.3	380.1	--
CSR-3	⊙	Grounds, Landside Lock	454.9	434.1	379.5	--
CSR-4	⊙	Grounds, Landside Lock	455.5	441.6	354.4	16 Aug 74
CSR-5	⊙	Grounds, Landside Lock	458.6	436.6	382.6	--
CSR-6	⊙	Grounds, Landside Lock	456.7	442.7	380.9	22 Aug 74
CSR-7	⊙	Grounds, Landside Lock	465.1	442.3	389.3	16 Jul 74
CSR-8	⊙	Grounds, Landside Lock	463.6	445.6	388.2	9 Sep 74
CSR-9	⊙	Grounds, Landside Lock	466.5	442.3	390.9	--
CSR-10	⊙	Grounds, Landside Lock	467.4	442.4	367.8	22 Aug 74
CSR-11	⊙	Grounds, Landside Lock	466.6	447.6	391.3	26 Aug 74
CSR-12	⊙	Grounds, Landside Lock	467.7	446.0	392.5	3 Sep 74
CSR-13	⊙	Grounds, Landside Lock	467.1	444.6	392.6	22 May 74
CSR-14	⊙	Grounds, Landside Lock	467.1	446.3	392.5	13 Sep 74
CSR-15	⊙	Grounds, Landside Lock	467.7	446.9	392.6	--
CSR-16	⊙	Grounds, Landside Lock	455.5	443.7	389.6	--
CSR-17	⊙	Grounds, Landside Lock	466.2	446.4	389.9	--
CSR-18	⊙	Grounds, Landside Lock	459.5	446.6	384.3	18 Sep 74
CSR-19	⊙	Grounds, Landside Lock	466.5	449.0	406.1	23 Sep 74
SR WES GW-1-77	◉	Lower Guide Wall	459.0	428.1	402.0	4 Jun 77
SR WES GW-2-77	◉	Lower Guide Wall	459.0	431.5	404.2	9 Jun 77

(Continued)

(Sheet 1 of 3)

Table 1 (Continued)

Boring No.	Type of Boring	Location	El. Top of Boring, ft	El. Top of Rock, ft	El. Bottom of Boring, ft	Start Date
SR WES GWB-1-77	▲	Backfill, LGW	458.5	431.8	430.8	14 Jun 77
SR WES GWB-2-77	▲	Backfill, LGW	458.5	--	441.0	20 Jun 77
SR WES GWB-3-77	▲	Backfill LGW	458.5	440.0	440.0	6 Aug 77
SR WES D-14-77	◉	Dam, DS	418.2	418.2	398.1	25 Jul 77
SR WES D-15-77	◉	Dam, DS	428.0	428.0	407.3	23 Jul 77
SR WES D-16-77	◉	Dam, DS	428.6	428.6	408.7	20 Jul 77
SR WES D-17-77	◉	Dam, DS	428.2	428.2	408.4	19 Jul 77
SR WES L-1-77	◉	Landlock Wall	464.0	415.5	391.1	27 Jul 77
SR WES D-11-77	◉	Head Gates Pier 16	469.0	427.8	408.2	27 Jun 77
SR WES D-12-77	◉	Taintor Gate Pier No. 6	472.7	416.5	392.7	4 Jul 77
SR WES D-13-77	◉	Fixed Dam	464.0	432.9	413.0	8 Jul 77
SR WES D-35-78	◉	Dam, DS	434.9	434.9	425.0	28 Apr 78
SR WES D-36-78	◉	Dam, DS	438.1	438.1	417.2	31 Apr 78
SR WES D-37-78	◉	Dam, DS	430.8	430.8	419.1	1 Aug 78
SR WES D-38-78	◉	Dam, DS	430.8	430.8	418.8	2 Aug 78
SR WES D-39-78	◉	Dam, DS	432.8	432.8	423.0	4 Aug 78
SR WES D-40-78	◉	Dam, DS	437.4	437.4	428.4	5 Aug 78
SR WES D-41-78	◉	Dam, DS	429.6	415.3	389.7	7 Aug 78
SR WES D-42-78	◉	Dam, DS	429.0	416.5	390.6	9 Aug 78
SR WES D-43-78	◉	Dam, DS	430.0	418.9	407.8	11 Aug 78
SR WES D-44-78	◉	Dam, DS	420.6	420.6	411.6	11 Aug 78
SR WES D-45-78	◉	Dam, DS	418.5	418.5	409.7	14 Aug 78
SR WES D-46-78	◉	Dam, DS	415.0	415.0	393.5	22 Aug 78
SR WES D-47-78	◉	Dam, DS	419.0	419.0	407.7	15 Aug 78
SR WES D-48-78	◉	Dam, DS	430.2	418.9	408.2	16 Aug 78
SR WES D-49-78	◉	Dam, DS	415.0	415.0	403.5	17 Aug 78
SR WES D-50-78	◉	Dam, DS	426.0	422.0	391.2	19 Aug 78
SR WES D-51-78	◉	Dam, DS	435.4	425.4	393.2	24 Aug 78
SR WES D-52-78	◉	Dam, DS	437.0	437.0	366.9	28 Aug 78

(Continued)

Table 1 (Concluded)

Boring No.	Type of Boring	Location	El. Top of Boring, ft	El. Top of Rock, ft	El. Bottom of Boring, ft	Start Date
SR WES D-56-78	●	Taintor Gate Pier No. 11	467.5	416.7	397.2	12 Sep 78
SR WES D-57-78	●	Taintor Gate Pier No. 11	467.5	419.6	296.1	14 Sep 78
SR WES D-58-78	●	Taintor Gate Pier No. 10	467.5	417.0	396.9	16 Sep 78
SR WES D-59-78	●	Taintor Gate Pier No. 10	467.5	422.7	396.5	18 Sep 78
SR WES D-60-79	●	Head Gate Bay 7	469.0	439.7	434.2	16 May 79
SR WES D-61-79	●	Head Gate Pier 21	469.0	427.2	421.4	18 May 79
SR WES D-62-79	●	Taintor Gate Bay 1	433.7	419.5	414.6	21 May 79
SR WES D-63-79	●	Taintor Gate Bay 4	429.2	417.0	411.7	28 May 79
SR WES D-64-79	●	Ice Chute	432.8	419.4	413.7	25 May 79
SR WES D-65-79	●	Taintor Gate Bay 2	429.2	419.6	412.9	30 May 79
SR WES D-66-79	◉	Head Gate Bay 8	469.0	439.8	422.7	1 Jun 79
SR WES D-67-79	◉	Head Gate Bay 6	469.0	440.3	422.5	5 Jun 79
SR WES D-68-79	◉	Head Gate Bay 2	469.0	439.9	422.6	8 Jun 79
SR WES D-69-79	◉	Head Gate Bay 11	469.0	439.2	420.0	12 Jun 79
SR WES D-70-79	●	Head Gate Bay 14	469.0	434.0	424.7	18 Jun 79
SR WES D-71-79	●	Head Gate Pier 11	469.0	435.5	417.1	21 Jun 79
SR WES D-72-79	●	Head Gate Pier 11	469.0	438.0	422.1	24 Jun 79
SR WES D-73-79	●	Head Gate Pier 4	469.0	434.5	421.6	27 Jun 79
SR WES D-74-79	◉	Head Gate Pier 4	469.0	438.5	426.4	29 Jun 79
SR WES D-75-79	◉	Head Gate DS, Pier 11	443.3	438.5	420.5	8 Jul 79
SR WES D-76-79	◉	Head Gate DS, Pier 4	448.6	439.0	430.3	10 Jul 79

▲ Combined drive sample and core with piezometer installed.
▲ Combined drive sample and core; SACDI borings with 4-in. core recovered and WES borings with 6-in. core recovered.
◉ 6-in. core hole.
● NX core hole.
US = upstream, DS = downstream.
LOW = lower guide wall.
El = elevation in feet, msl 1929 revised at Starved Rock Lock & Dam.

(Sheet 3 of 3)

Table 2

WES Core from Starved Rock Lock and Dam,

Illinois Waterway, Chicago District (Compliance Phase)

WES Reference	Drill Hole No.	Date Rec'd	Core Diam, in.	Box No.	Depth, ft	Elevation, ft Depth Intervals	Elevation, ft Top of Hole	Remarks
CHI-13 CON 45(A)	SR-WES L1-77	8/15/77	6	1 of 17	0.0- 4.5	464.0-459.5	464.0	(Vertical) Concrete
CHI-13 CON 45(B)	SR-WES L1-77	8/15/77	6	2	4.5- 5.9	459.5-458.1		(Vertical) Concrete
CHI-13 CON 45(C)	SR-WES L1-77	8/15/77	6	3	5.9-10.4	458.1-453.6		(Vertical) Concrete
CHI-13 CON 45(D)	SR-WES L1-77	8/15/77	6	4	10.4-14.5	453.6-449.5		(Vertical) Concrete
CHI-13 CON 45(E)	SR-WES L1-77	8/15/77	6	5	14.5-19.0	449.5-445.0		(Vertical) Concrete
CHI-13 CON 45(F)	SR-WES L1-77	8/15/77	6	6	19.0-23.5	445.0-440.5		(Vertical) Concrete
CHI-13 CON 45(G)	SR-WES L1-77	8/15/77	6	7	23.5-27.9	440.5-436.1		(Vertical) Concrete
CHI-13 CON 45(H)	SR-WES L1-77	8/15/77	6	8	27.9-30.4	436.1-433.6		(Vertical) Concrete
CHI-13 CON 45(H)	SR-WES L1-77	8/15/77	6	8	35.5-37.4	428.6-426.6		(Vertical) Concrete
CHI-13 CON 45(I)	SR-WES L1-77	8/15/77	6	9	30.4-34.4	433.6-429.6		(Vertical) Concrete
CHI-13 CON 45(I)	SR-WES L1-77	8/15/77	6	9	37.4-38.1	426.6-425.9		(Vertical) Concrete
CHI-13 CON 45(J)	SR-WES L1-77	8/15/77	6	10	34.4-35.4	429.6-428.6		(Vertical) Concrete
CHI-13 CON 45(J)	SR-WES L1-77	8/15/77	6	10	38.1-40.7	425.9-423.3		(Vertical) Concrete
CHI-13 CON 45(K)	SR-WES L1-77	8/15/77	6	11	40.7-44.0	423.3-420.0		Concrete
CHI-13 DC 11 (A)	SR-WES L1-77	8/15/77	6	12	44.0-48.5	420.0-415.5		Sandstone
CHI-13 DC 11 (B)	SR-WES L1-77	8/15/77	6	13	48.5-52.7	415.5-411.3		Sandstone
CHI-13 DC 11 (C)	SR-WES L1-77	8/15/77	6	14	52.7-56.2	411.3-407.8		Sandstone
CHI-13 DC 11 (D)	SR-WES L1-77	8/15/77	6	15	56.2-60.6	407.8-403.4		Sandstone
CHI-13 DC 11 (E)	SR-WES L1-77	8/15/77	6	16	60.6-65.2	403.4-398.8		Sandstone
CHI-13 DC 11 (F)	SR-WES L1-77	8/15/77	6	17 of 17	65.2-67.9	398.8-396.1		Sandstone
CHI-13 CON 46(A)	SR-WES D11-77	7/19/77	6	1 of 17	0.0- 4.6	469.0-464.4	469.0	(Vertical) Concrete
CHI-13 CON 46(B)	SR-WES D11-77	7/19/77	6	2	4.6- 8.8	464.4-460.2		Concrete
CHI-13 CON 46(C)	SR-WES D11-77	7/19/77	6	3	8.8-12.9	460.2-456.1		Concrete
CHI-13 CON 46(D)	SR-WES D11-77	7/19/77	6	4	12.9-17.5	456.1-451.5		Concrete
CHI-13 CON 46(E)	SR-WES D11-77	7/19/77	6	5	17.5-21.2	451.5-447.8		Concrete
CHI-13 CON 46(F)	SR-WES D11-77	7/19/77	6	6	21.2-25.6	447.8-443.4		Concrete
CHI-13 CON 46(G)	SR-WES D11-77	7/19/77	6	7	25.6-29.5	443.4-439.5		Concrete
CHI-13 CON 46(H)	SR-WES D11-77	7/19/77	6	8	29.5-32.5	439.5-436.5		Concrete

(Continued)

(Sheet 1 of 3)

Table 2 (Continued)

WES Reference	Drill Hole No.	Date Rec'd	Core Diam, in.	Box No.	Depth, ft	Elevation, ft Depth Intervals	Elevation, ft Top of Hole	Remarks
CHI-13 CON 46(I)	SR-WES D11-77	7/19/77	6	9	32.5-35.7	436.5-433.3		Concrete
CHI-13 CON 46(J)	SR-WES D11-77	7/19/77	6	10	35.7-38.1	433.3-430.9		Concrete
CHI-13 CON 46(J)	SR-WES D11-77	7/19/77	6	10	40.6-41.6	438.4-427.4		Concrete
CHI-13 DC 12 (A)	SR-WES D11-77	7/19/77	6	11	38.1-40.6	430.9-428.4		Shale
CHI-13 DC 12 (B)	SR-WES D11-77	7/19/77	6	11	41.6-41.9	427.4-427.1		Sandstone
CHI-13 DC 12 (B)	SR-WES D11-77	7/19/77	6	12	41.9-44.9	427.1-424.1		Sandstone
CHI-13 DC 12 (C)	SR-WES D11-77	7/19/77	6	13	44.9-47.8	424.1-421.2		Sandstone
CHI-13 DC 12 (D)	SR-WES D11-77	7/19/77	6	14	47.8-51.6	421.2-417.4		Sandstone
CHI-13 DC 12 (E)	SR-WES D11-77	7/19/77	6	15	51.6-54.2	417.4-414.8		Sandstone
CHI-13 DC 13 (F)	SR-WES D11-77	7/19/77	6	16	54.2-58.5	414.8-410.5		Sandstone
CHI-13 DC 12 (G)	SR-WES D11-77	7/19/77	6	17 of 17	58.5-60.8	410.5-408.2		Sandstone
CHI-13 CON 47(A)	SR-WES D12-77	7/19/77	6	1 of 20	0.0- 1.6	472.7-471.1	472.7	(Vertical) Concrete
CHI-13 CON 47(A)	SR-WES D12-77	7/19/77	6	1	1.9- 3.8	470.8-468.9		Concrete
CHI-13 CON 47(B)	SR-WES D12-77	7/19/77	6	2	1.6- 1.9	471.1-470.8		Concrete
CHI-13 CON 47(B)	SR-WES D12-77	7/19/77	6	2	3.8- 6.2	468.9-466.5		Concrete
CHI-13 CON 47(C)	SR-WES D12-77	7/19/77	6	3	6.2-10.0	466.5-467.7		Concrete
CHI-13 CON 47(D)	SR-WES D12-77	7/19/77	6	4	10.0-13.5	462.7-459.2		Concrete
CHI-13 CON 47(E)	SR-WES D12-77	7/19/77	6	5	13.5-15.6	459.2-457.1		Concrete
CHI-13 CON 47(E)	SR-WES D12-77	7/19/77	6	5	17.8-19.7	454.9-453.0		Concrete
CHI-13 CON 47(F)	SR-WES D12-77	7/19/77	6	6	15.6-17.8	457.1-454.9		Concrete
CHI-13 CON 47(F)	SR-WES D12-77	7/19/77	6	6	17.8-21.9	454.9-450.8		Concrete
CHI-13 CON 47(G)	SR-WES D12-77	7/19/77	6	7	21.9-26.0	450.8-446.7		Concrete
CHI-13 CON 47(H)	SR-WES D12-77	7/19/77	6	8	26.0-30.6	446.7-442.1		Concrete
CHI-13 CON 47(I)	SR-WES D12-77	7/19/77	6	9	30.6-35.4	442.1-437.3		Concrete
CHI-13 CON 47(J)	SR-WES D12-77	7/19/77	6	10	35.4-40.0	437.3-432.7		Concrete
CHI-13 CON 47(K)	SR-WES D12-77	7/19/77	6	11	40.0-43.8	432.7-428.9		Concrete
CHI-13 CON 47(L)	SR-WES D12-77	7/19/77	6	12	43.8-48.2	428.9-424.5		Concrete
CHI-13 CON 47(M)	SR-WES D12-77	7/19/77	6	13	48.2-53.0	424.5-419.7		Concrete
CHI-13 CON 47(N)	SR-WES D12-77	7/19/77	6	14	53.0-57.6	419.7-415.1		Concrete, Sandstone
CHI-13 DC 13 (A)	SR-WES D12-77	7/19/77	6	15	57.6-61.7	415.1-411.0		Sandstone
CHI-13 DC 13 (B)	SR-WES D12-77	7/19/77	6	16	61.7-65.8	411.0-406.9		Sandstone

(Continued)

Table 2 (Concluded)

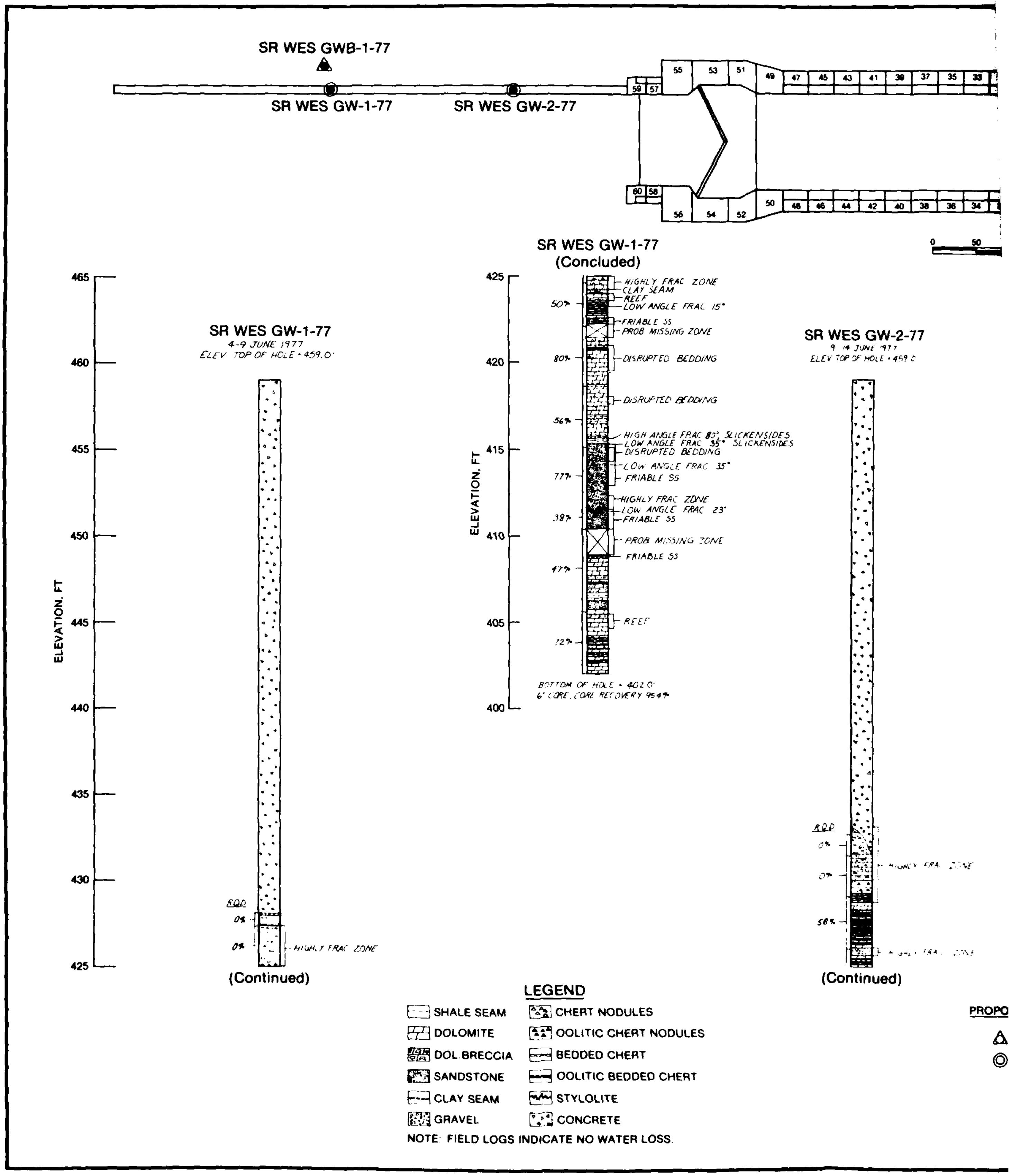
WES Reference	Drill Hole No.	Date Rec'd	Core Diam, in.	Box No.	Depth, ft	Elevation, ft Depth Intervals	Elevation, ft Top of Hole	Remarks
CHI-13 DC 13 (C)	SR-WES D12-77	7/19/77	6	17	65.8-70.1	406.9-402.6		Sandstone
CHI-13 DC 13 (D)	SR-WES D12-77	7/19/77	6	18	70.1-74.3	402.6-398.4		Sardstone
CHI-13 DC 13 (E)	SR-WES D12-77	7/19/77	6	19	74.3-78.6	398.4-394.1		Sandstone
CHI-13 DC 13 (F)	SR-WES D12-77	7/19/77	6	20 of 20	78.6-80.0	394.1-392.7		Sandstone
CHI-13 CON 48(A)	SR-WES D13-77	7/19/77	6	1 of 12	0.0- 4.9	464.0-459.1	464.0	(Vertical) Concrete
CHI-13 CON 48(B)	SR-WES D13-77	7/19/77	6	2 of 12	4.9- 7.3	459.1-456.7		Concrete
CHI-13 CON 48(B)	SR-WES D13-77	7/19/77	6	2 of 12	10.5-11.5	453.5-452.5		Concrete
CHI-13 CON 48(C)	SR-WES D13-77	7/19/77	6	3	7.3-10.5	456.7-453.5		Concrete
CHI-13 CON 48(C)	SR-WES D13-77	7/19/77	6	3	15.1-16.6	448.9-447.4		Concrete
CHI-13 CON 48(D)	SR-WES D13-77	7/19/77	6	4	11.5-15.1	452.5-448.9		Concrete
CHI-13 CON 48(D)	SR-WES D13-77	7/19/77	6	4	16.6-17.5	447.4-446.5		Concrete
CHI-13 CON 48(E)	SR-WES D13-77	7/19/77	6	5	17.5-22.0	446.5-442.0		Concrete
CHI-13 CON 48(F)	SR-WES D13-77	7/19/77	6	6	22.0-26.2	442.0-437.8		Concrete
CHI-13 CON 48(G)	SR-WES D13-77	7/19/77	6	7	26.2-30.5	437.8-433.5		Concrete
CHI-13 DC 14 (A)	SR-WES D13-77	7/19/77	6	8	30.5-34.2	433.5-429.8		Concrete, Sandstone
CHI-13 DC 14 (B)	SR-WES D13-77	7/19/77	6	9	34.2-38.0	429.8-426.0		Sandstone
CHI-13 DC 14 (C)	SR-WES D13-77	7/19/77	6	10	38.0-41.6	426.0-422.4		Sandstone
CHI-13 DC 14 (D)	SR-WES D13-77	7/19/77	6	11	41.6-46.4	422.4-417.6		Sandstone
CHI-13 DC 14 (E)	SR-WES D13-77	7/19/77	6	12 of 12	46.4-51.0	417.6-413.0		Sandstone, Chert

Table 3

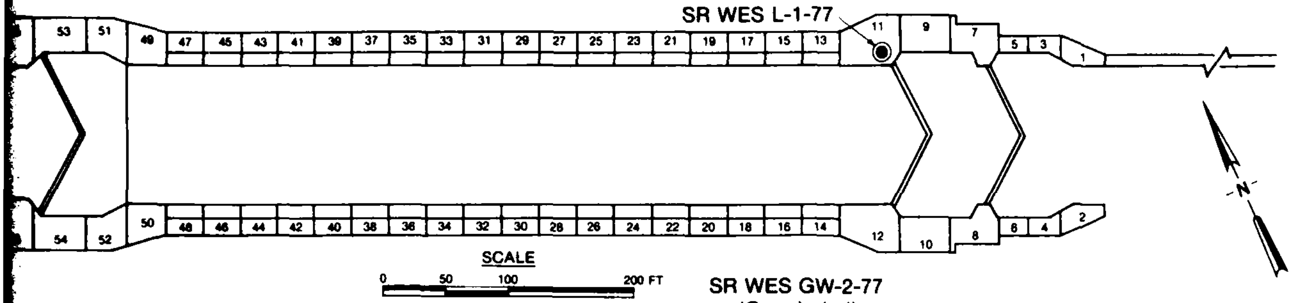
Test Results, Starved Rock Lock and Dam, Compliance Phase

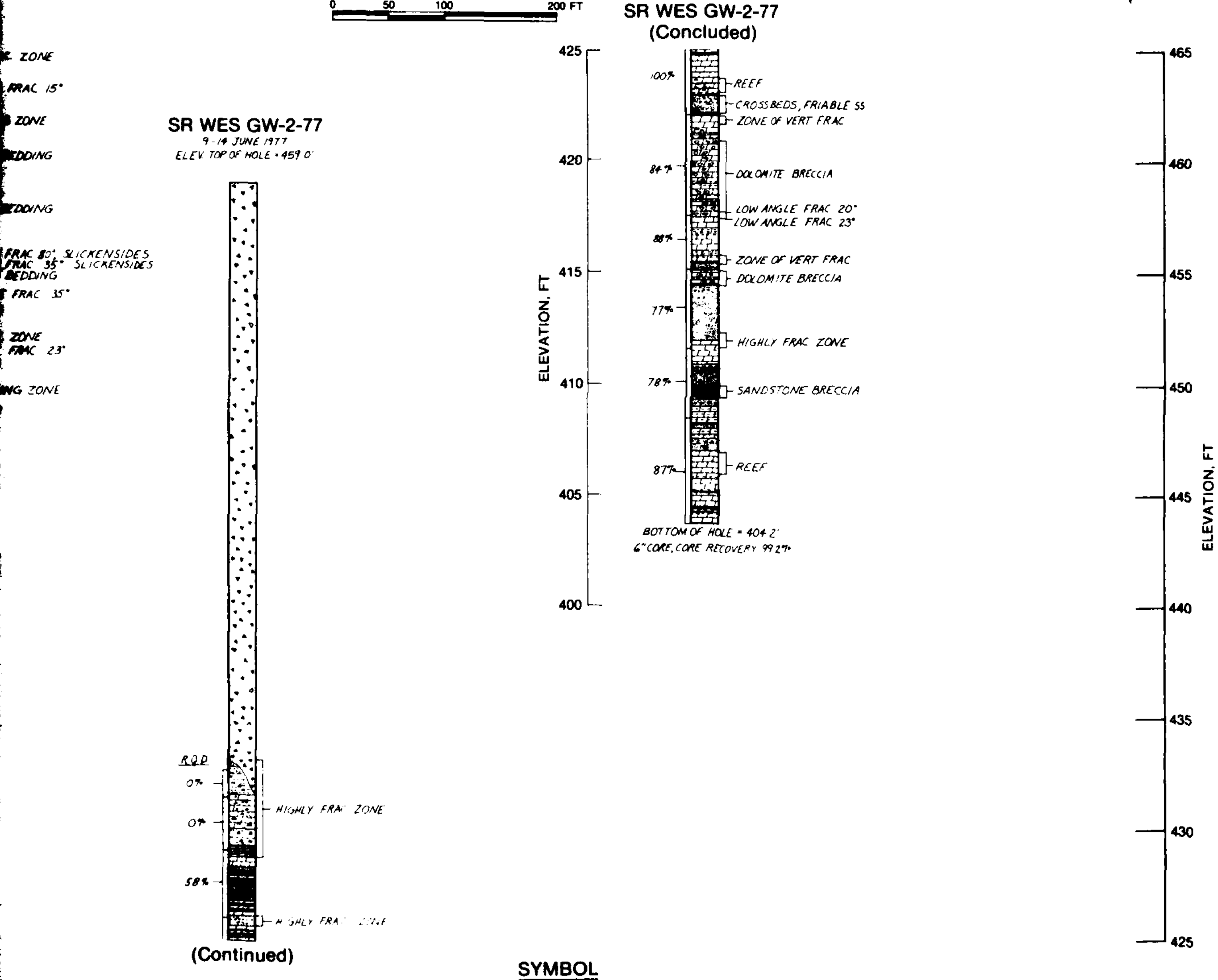
Drill Hole No. SR WES- -77	Elevation, ft	Characterization Tests: Effective Unit Wt γm, lb/ft^3	Dry Unit Wt γd, lb/ft^3	Water Content W, %	Comp Wave Velocity Vp, ft/sec	Comp. Strength UC, psi	Engineering Design Tests: Elastic Modulus, x 10^6 psi	Poisson's Ratio	Remarks
Concrete									
D-11	466.1	153.6	145.2	5.8	16,256	6470	5.13	0.21	
D-11	447.3	153.0	145.7	5.0	16,263	7420	6.78	0.25	
D-11	428.9	154.8	417.0	5.3	17,090	8410	6.67	0.17	
D-12	472.2	151.7	143.7	5.6	12,987	4510	1.31	0.10	Top 1 ft of core
D-12	470.2	153.0	146.4	4.5	14,285	3900	1.42	0.16	2.5 ft from top of core
D-12	467.5	152.3	143.3	6.3	15,625	8650	3.70	0.14	
D-12	445.2	156.7	149.0	5.2	16,393	7080	5.00	0.19	
D-12	418.2	150.5	140.4	7.2	15,873	6690	5.33	0.30	

Drill Hole No. SR WES- -77	Elevation, ft	Characterization Tests: Effective Unit Wt γm, lb/ft^3	Dry Unit Wt γd, lb/ft^3	Water Content W, %	Comp Wave Velocity Vp, ft/sec	Comp. Strength UC, psi	Engineering Design Tests: Elastic Modulus, x 10^6 psi	Poisson's Ratio	Rock Type
Dolomite and Sandstone									
D-11	426.3	162.3	145.5	3.7	15,847	7740	5.00	0.10	Dol
D-11	422.8	161.7	154.0	5.0	15,570	5030	2.94	0.20	Dol
D-12	413.8	156.7	152.7	2.6	15,735	2470	--	--	Dol
D-12	405.6	144.8	136.7	5.9	9,175	2930	2.10	0.26	Sandstone



SR WES GWB-1-77
SR WES GW-1-77
SR WES GW-2-77
SR WES GW-1-77
(Concluded)
SR WES GW-1-77
4-9 JUNE 1977
ELEV TOP OF HOLE = 459.0'
SR WES GW-2-77
ELEVATION, FT
(Continued)
(Continued)
BOTTOM OF HOLE = 402.0'
6" CORE, CORE RECOVERY 95.4%
LEGEND
SHALE SEAM
DOLOMITE
DOL BRECCIA
SANDSTONE
CLAY SEAM
GRAVEL
CHERT NODULES
OOLITIC CHERT NODULES
BEDDED CHERT
OOLITIC BEDDED CHERT
STYLOLITE
CONCRETE
NOTE: FIELD LOGS INDICATE NO WATER LOSS.





LES

RT

SYMBOL

PROPOSED	DESCRIPTION	COMPLETED
△	COMBINATION DRIVE SAMPLE AND CORED	▲
◎	6" CORE HOLE	●

COMPLIANCE PHASE

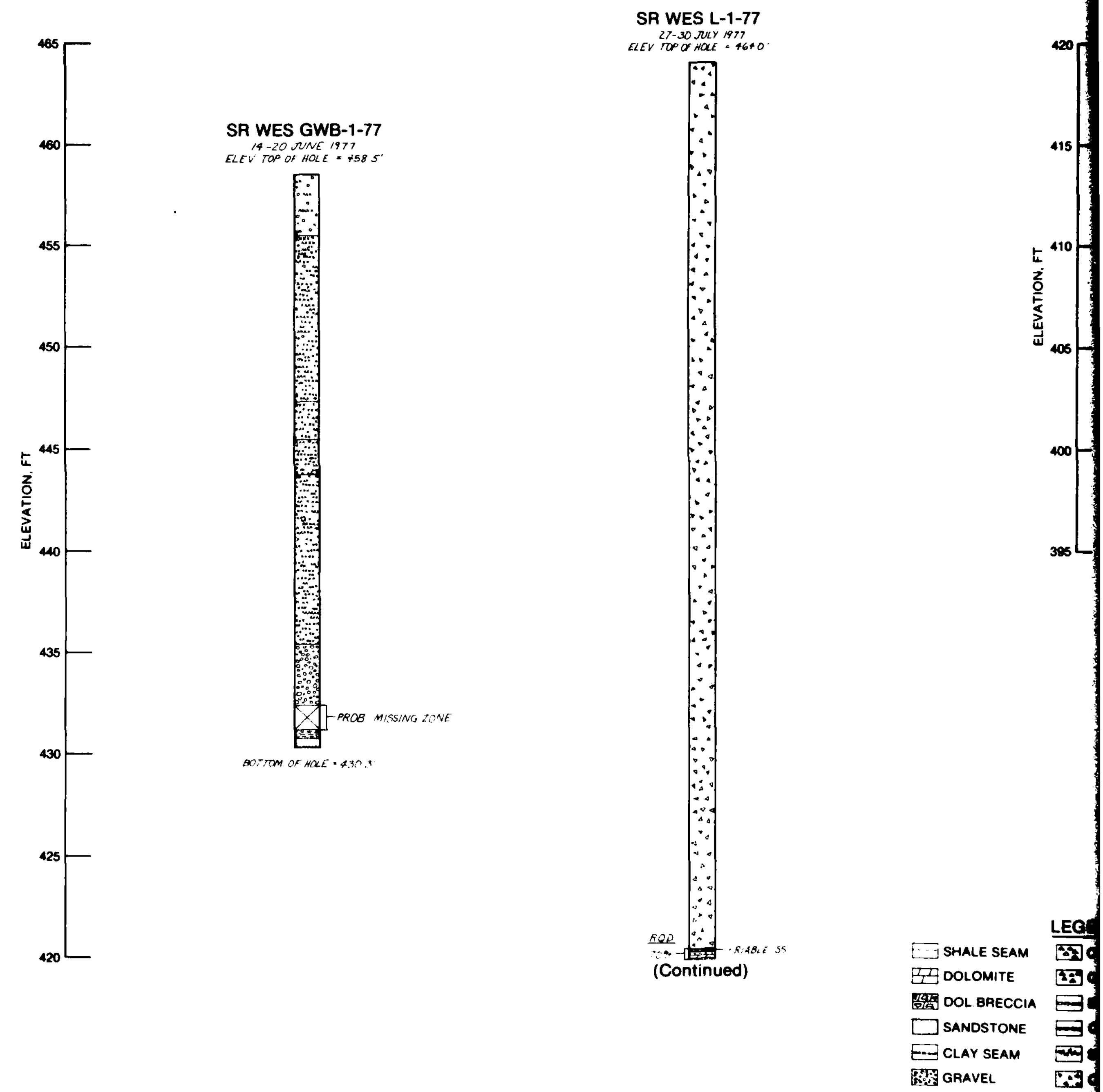
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

LOG OF BORINGS

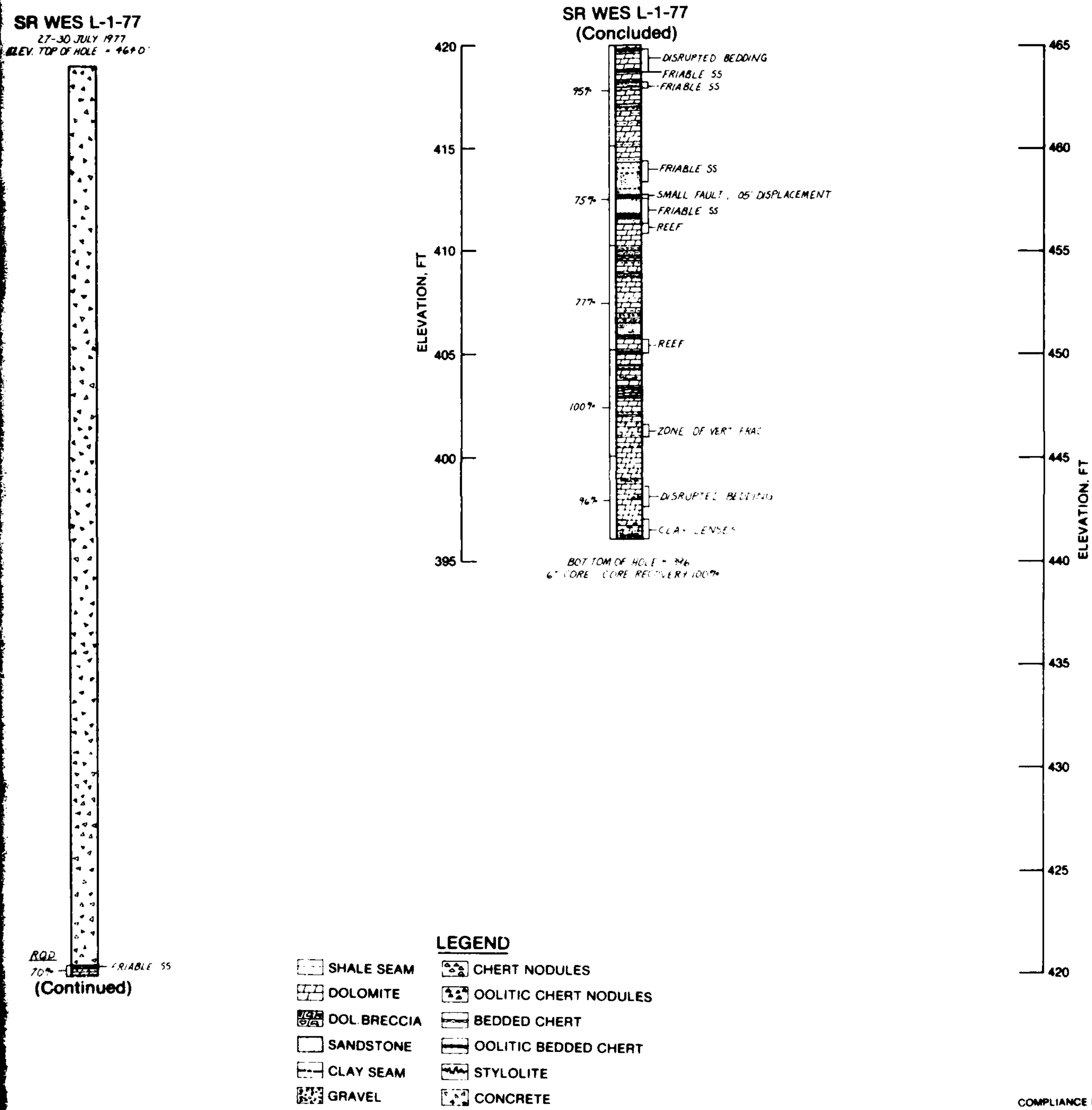
(SHEET 1 of 4)

PLATE 1

2


SR WES GWB-1-77
14-20 JUNE 1977
ELEV TOP OF HOLE = 458.5'
PROB MISSING ZONE
BOTTOM OF HOLE = 430.3'
SR WES L-1-77
27-30 JULY 1977
ELEV TOP OF HOLE = 464.0'
RQD
ELEVATION, FT
465
460
455
450
445
440
435
430
425
420
415
410
405
400
395
SHALE SEAM
DOLOMITE
DOL BRECCIA
SANDSTONE
CLAY SEAM
GRAVEL

(Continued)



COMPLIANCE PHASE

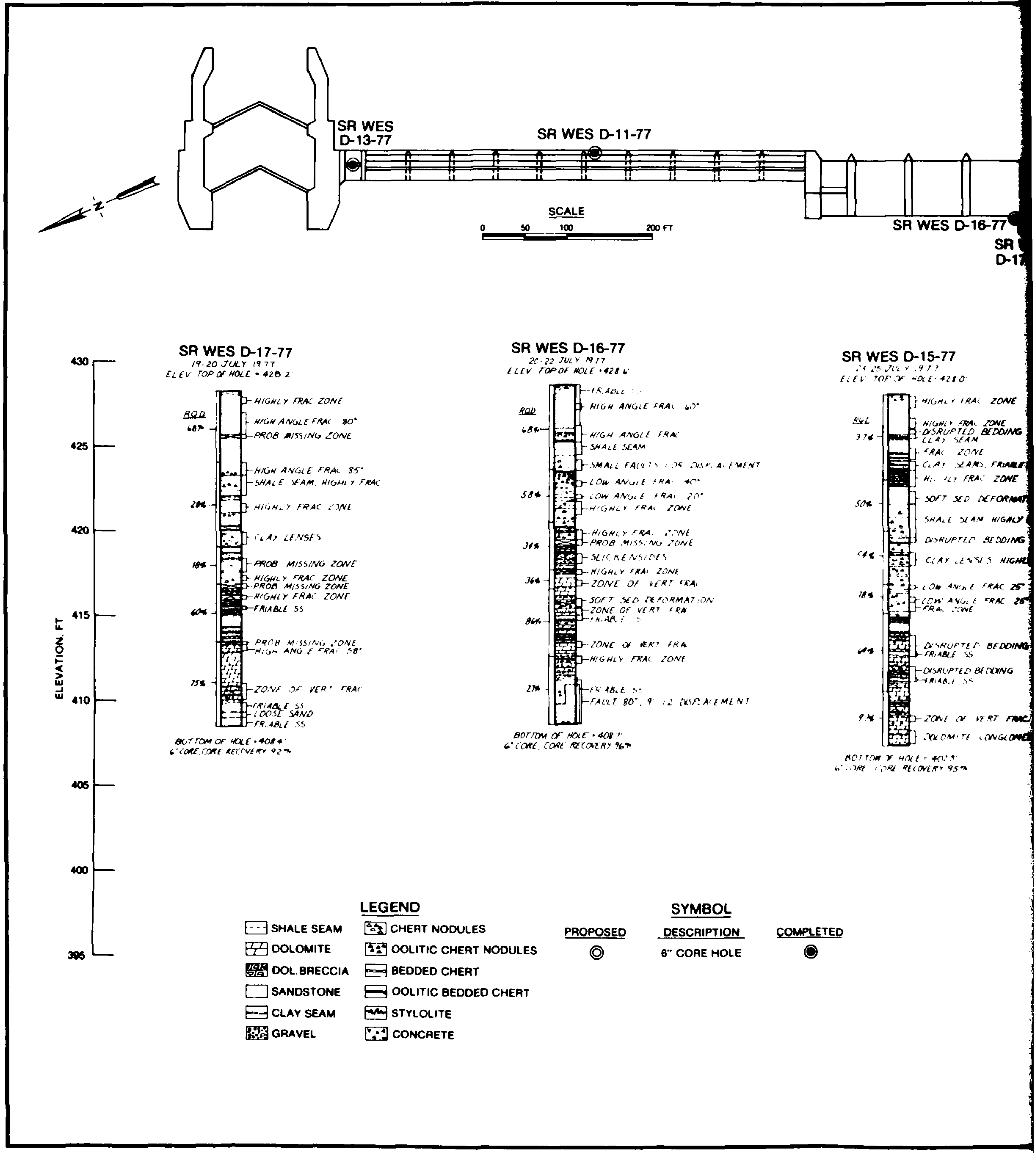
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

LOG OF BORINGS

(SHEET 2 of 4)

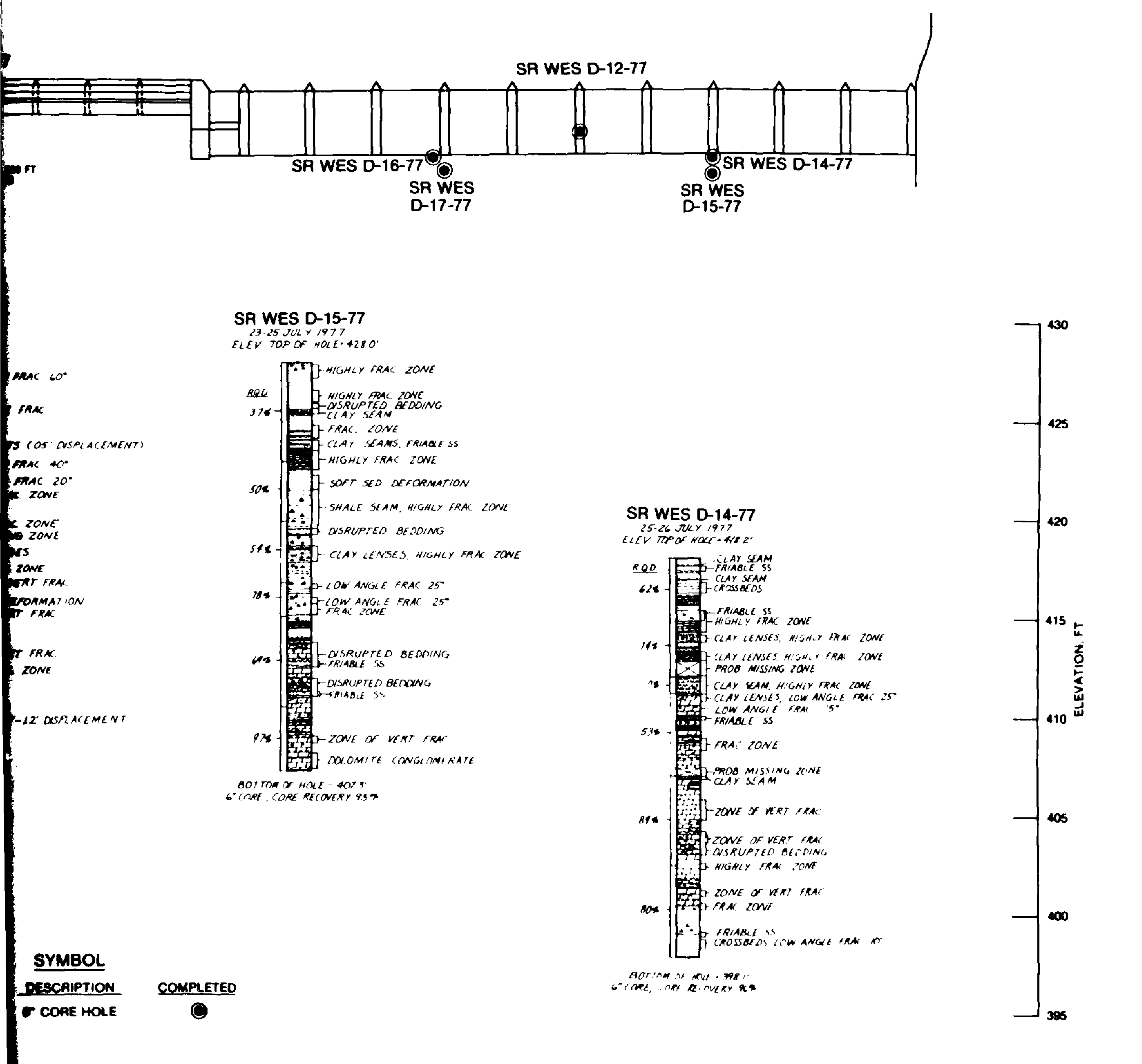
PLATE 2

2



SR WES D-13-77
SR WES D-11-77
SR WES D-16-77
SCALE
0 50 100 200 FT
ELEVATION, FT
SR WES D-17-77
19-20 JULY 1977
ELEV TOP OF HOLE • 428.2'
BOTTOM OF HOLE • 408.4'
6" CORE, CORE RECOVERY 92%
SR WES D-16-77
20-22 JULY 1977
ELEV TOP OF HOLE • 428.6'
BOTTOM OF HOLE • 408.7'
6" CORE, CORE RECOVERY 96%
SR WES D-15-77
LEGEND
SHALE SEAM
DOLOMITE
DOL.BRECCIA
SANDSTONE
CLAY SEAM
GRAVEL
CHERT NODULES
OOLITIC CHERT NODULES
BEDDED CHERT
OOLITIC BEDDED CHERT
STYLOLITE
CONCRETE
SYMBOL
PROPOSED
DESCRIPTION
COMPLETED
6" CORE HOLE

1



COMPLIANCE PHASE

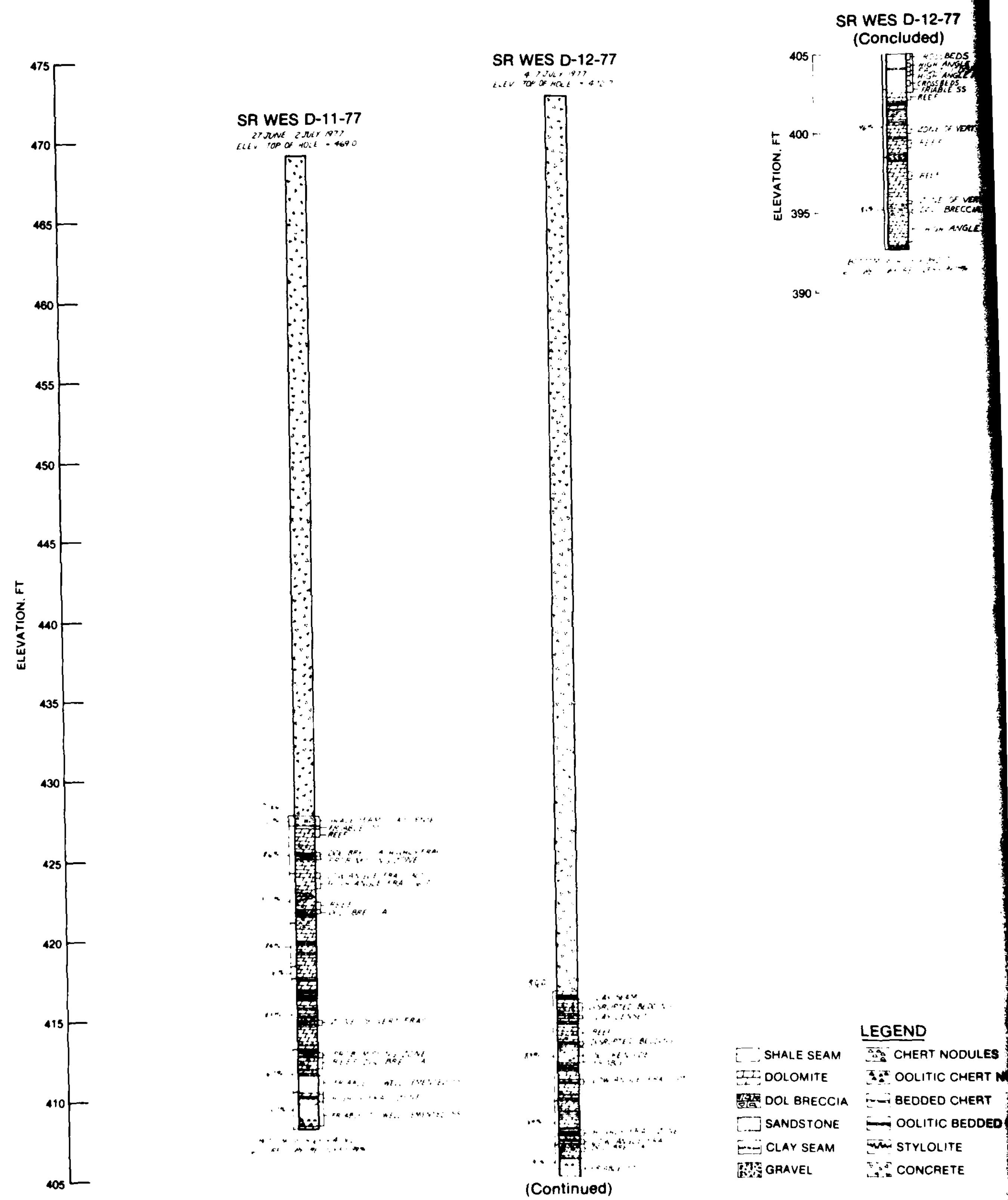
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

LOG OF BORINGS

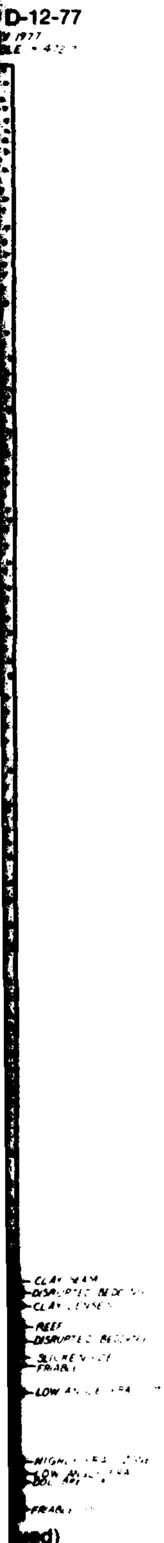
(SHEET 3 of 4)

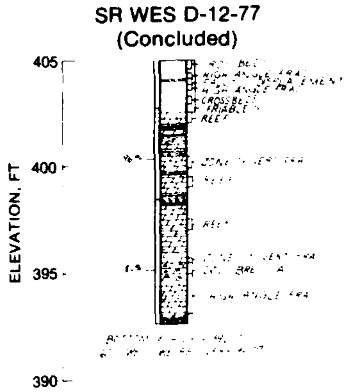
PLATE 3

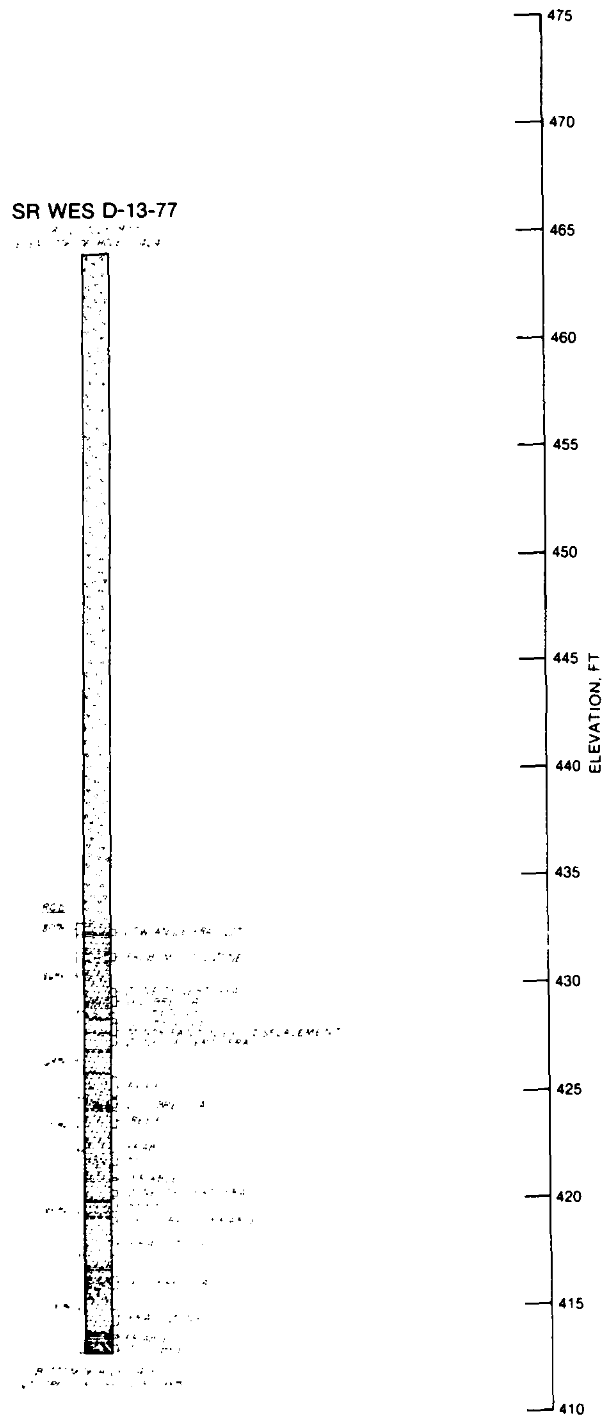
2



SR WES D-11-77
27 JUNE 2 JULY 1977
SR WES D-12-77
(Continued)
SR WES D-12-77
(Concluded)
ELEVATION, FT
475
470
465
460
455
450
445
440
435
430
425
420
415
410
405
400
395
390
LEGEND
SHALE SEAM
DOLOMITE
DOL BRECCIA
SANDSTONE
CLAY SEAM
GRAVEL
CHERT NODULES
BEDDED CHERT
STYLOLITE
CONCRETE







LEGEND

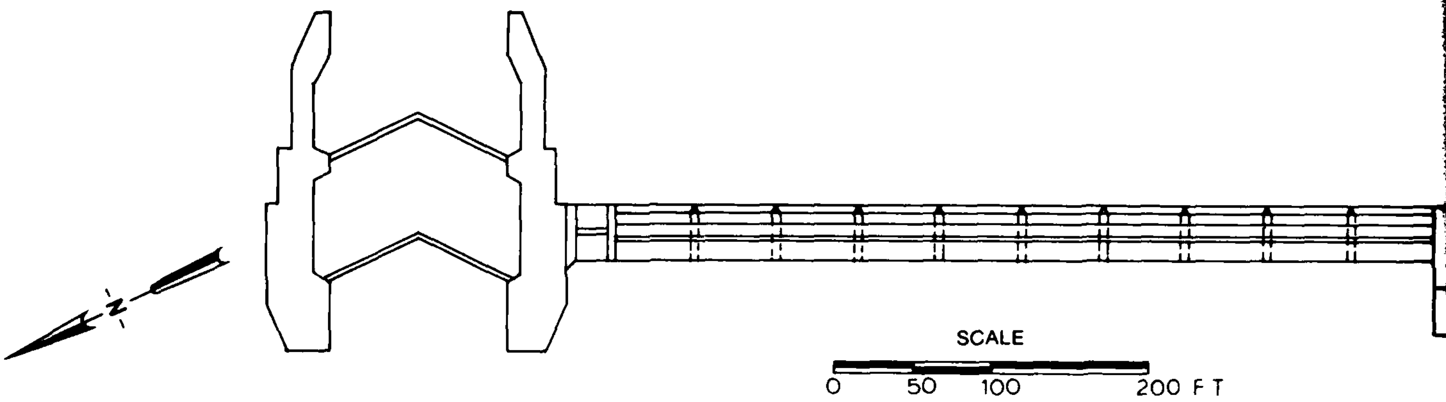
SHALE SEAM	CHERT NODULES
DOLOMITE	OOLITIC CHERT NODULES
DOL BRECCIA	BEDDED CHERT
SANDSTONE	OOLITIC BEDDED CHERT
CLAY SEAM	STYLOLITE
GRAVEL	CONCRETE

COMPLIANCE PHASE

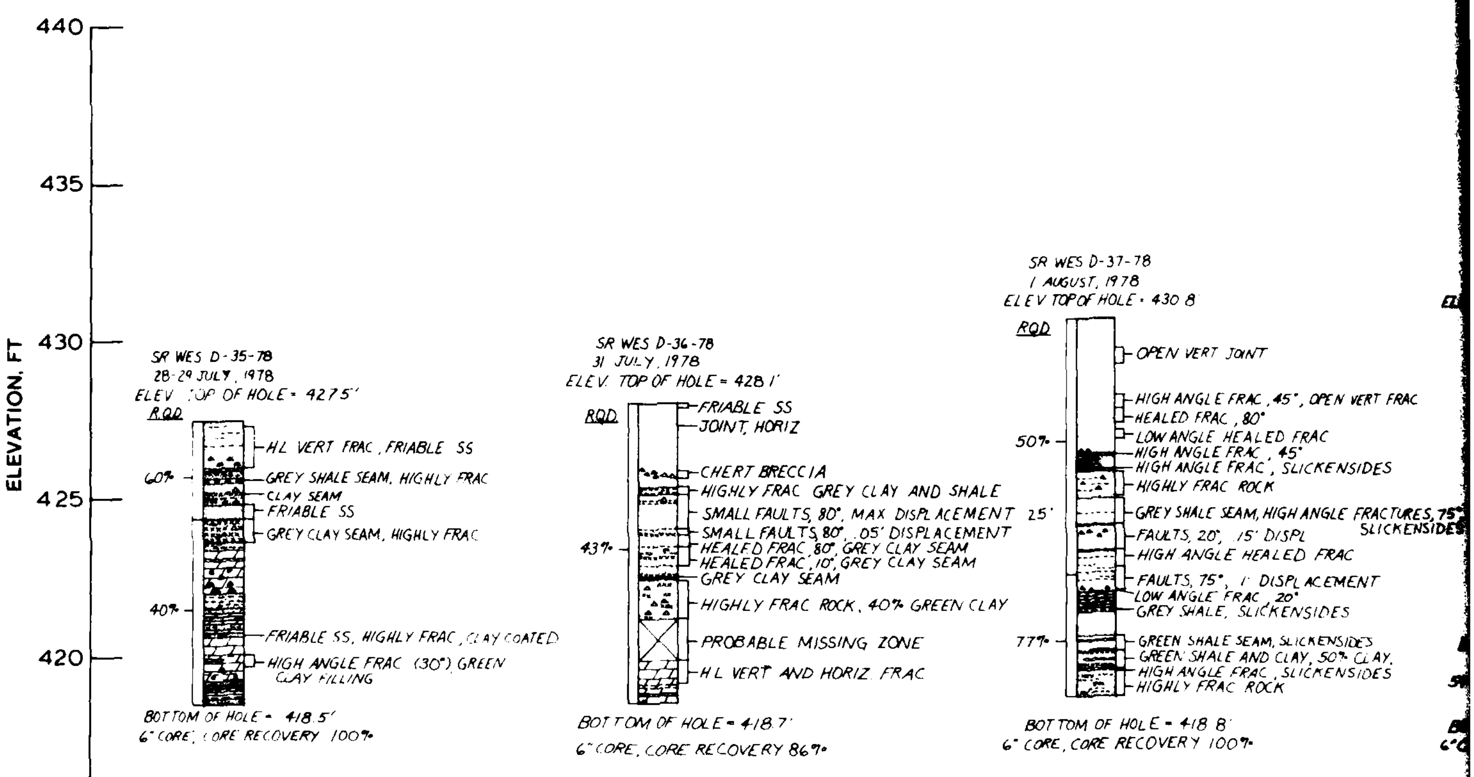
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

LOG OF BORINGS

(SHEET 4 of 4)



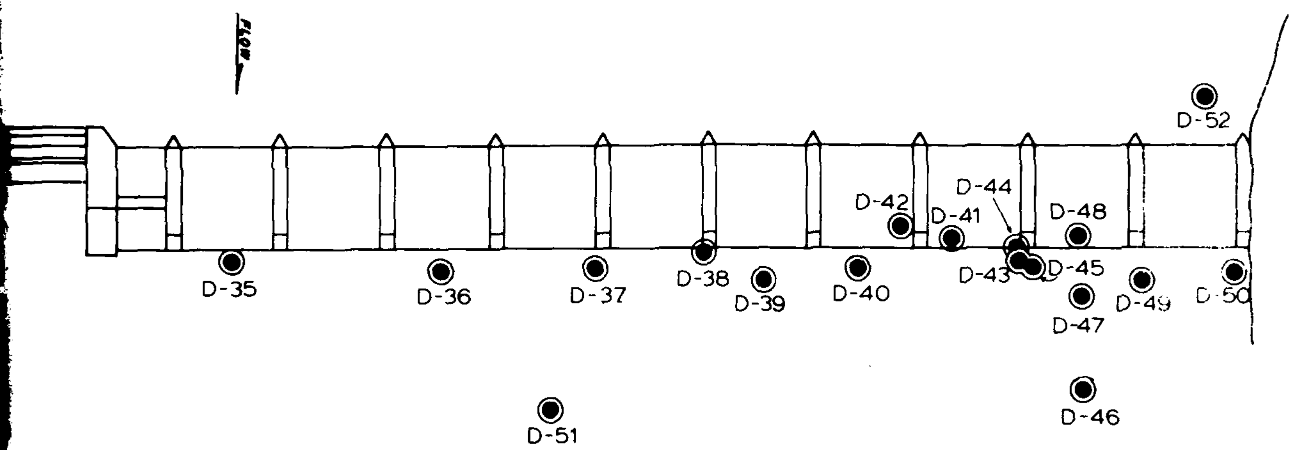
BORING LOC



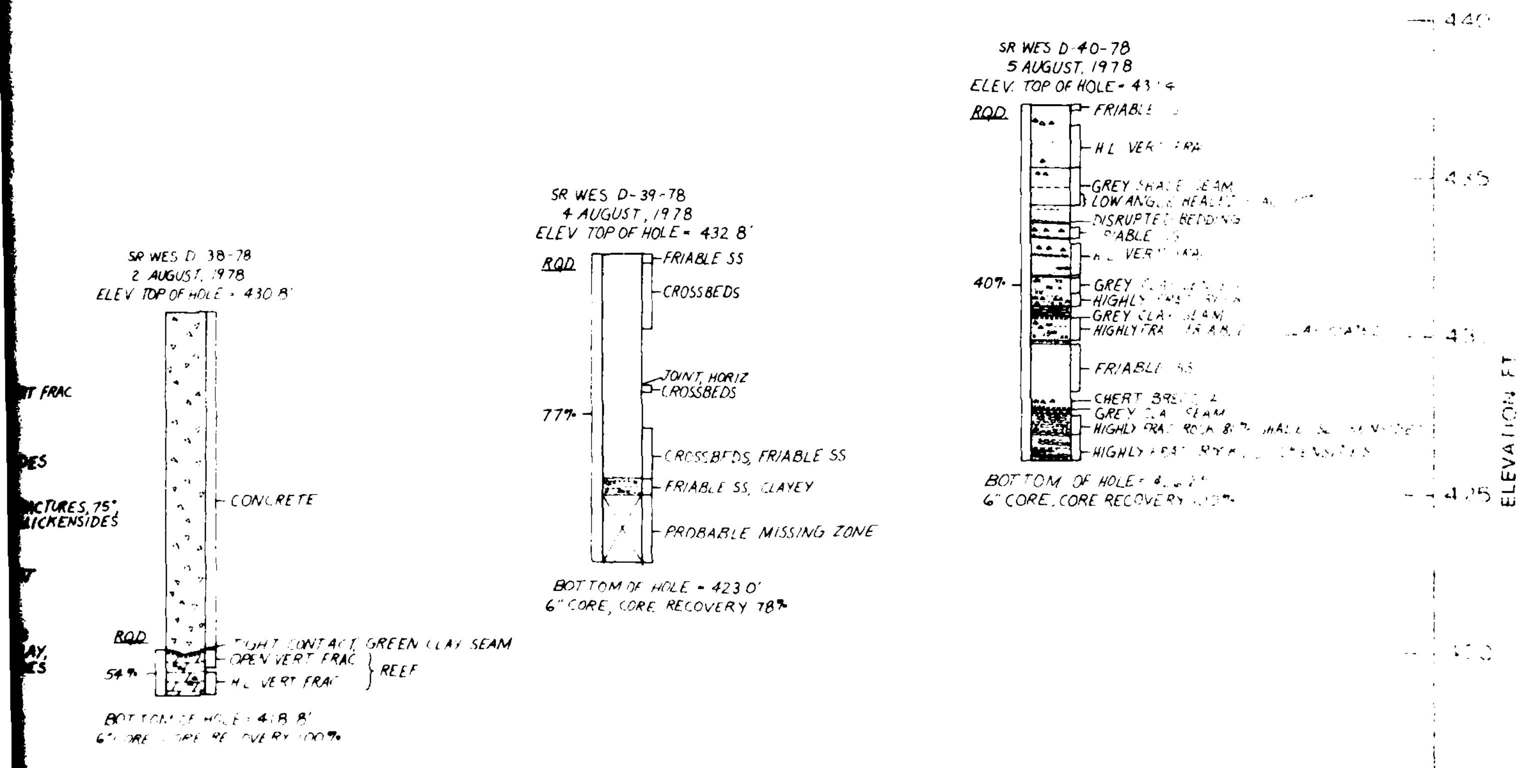
SYMBOLS

PROPOSED	DESCRIPTION	COMPLETED
◎	6" CORE HOLE	◉

CLAY SEAM
LOOSE MATERIAL
SILTSTONE
STYL
CONC
VUGS



G LOCATION PLAN



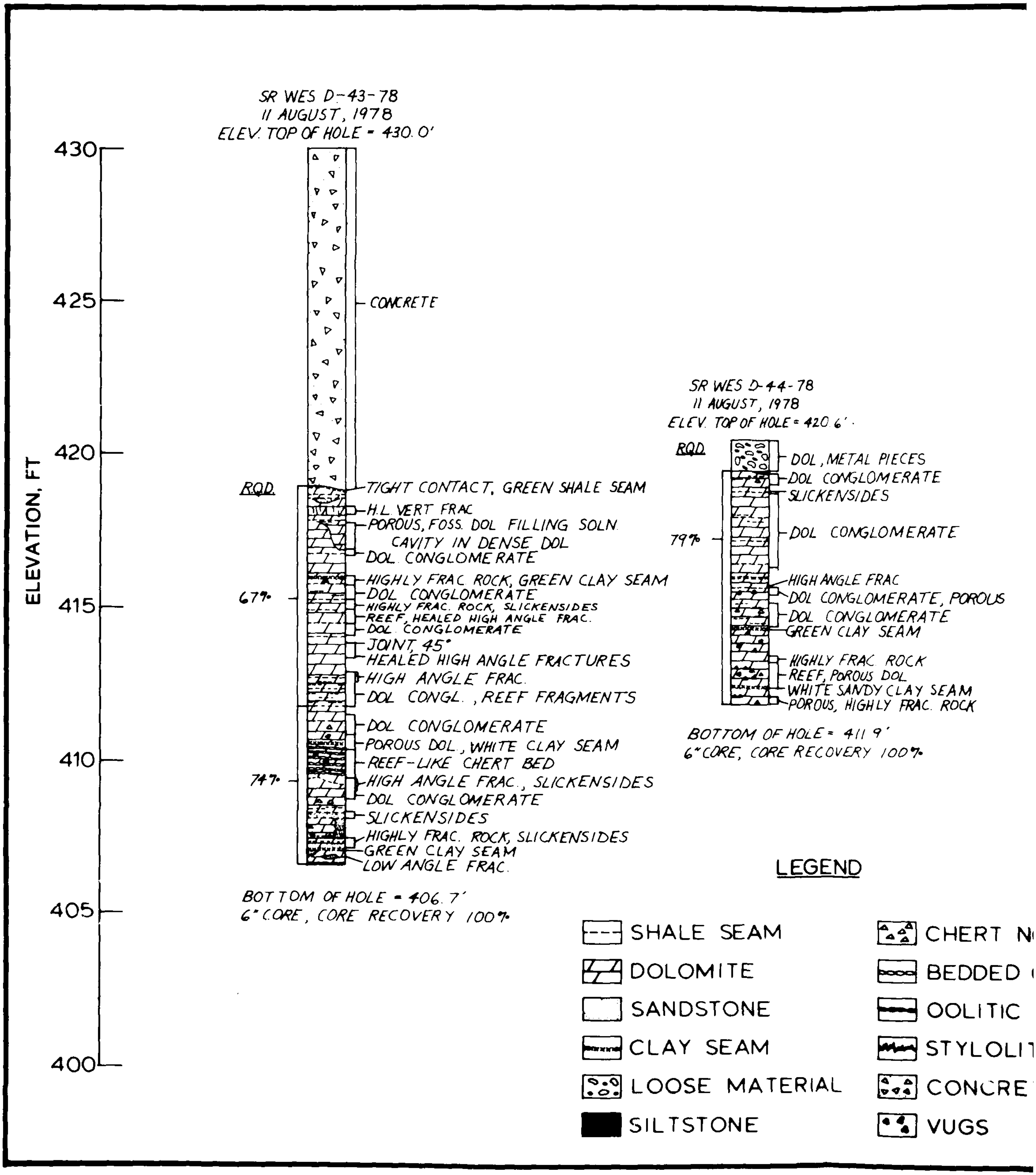
LEGEND

- STYLOLITE
- CONCRETE
- VUGS
- SHALE SEAM
- DOLOMITE
- SANDSTONE
- CHERT NODULES
- BEDDED CHERT
- OOLITIC BEDDED CHERT

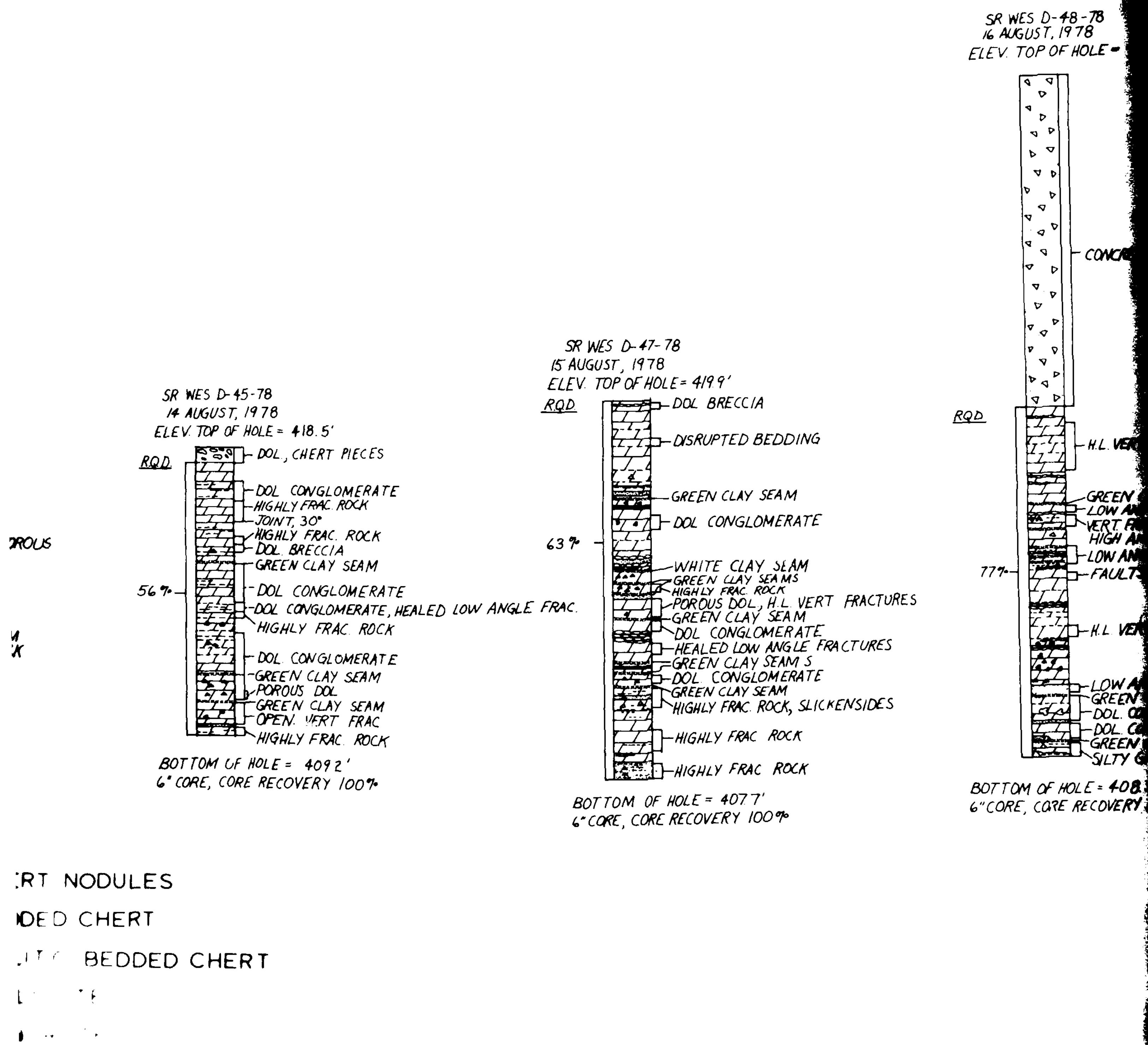
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
LOG OF BORINGS

PLATE 5

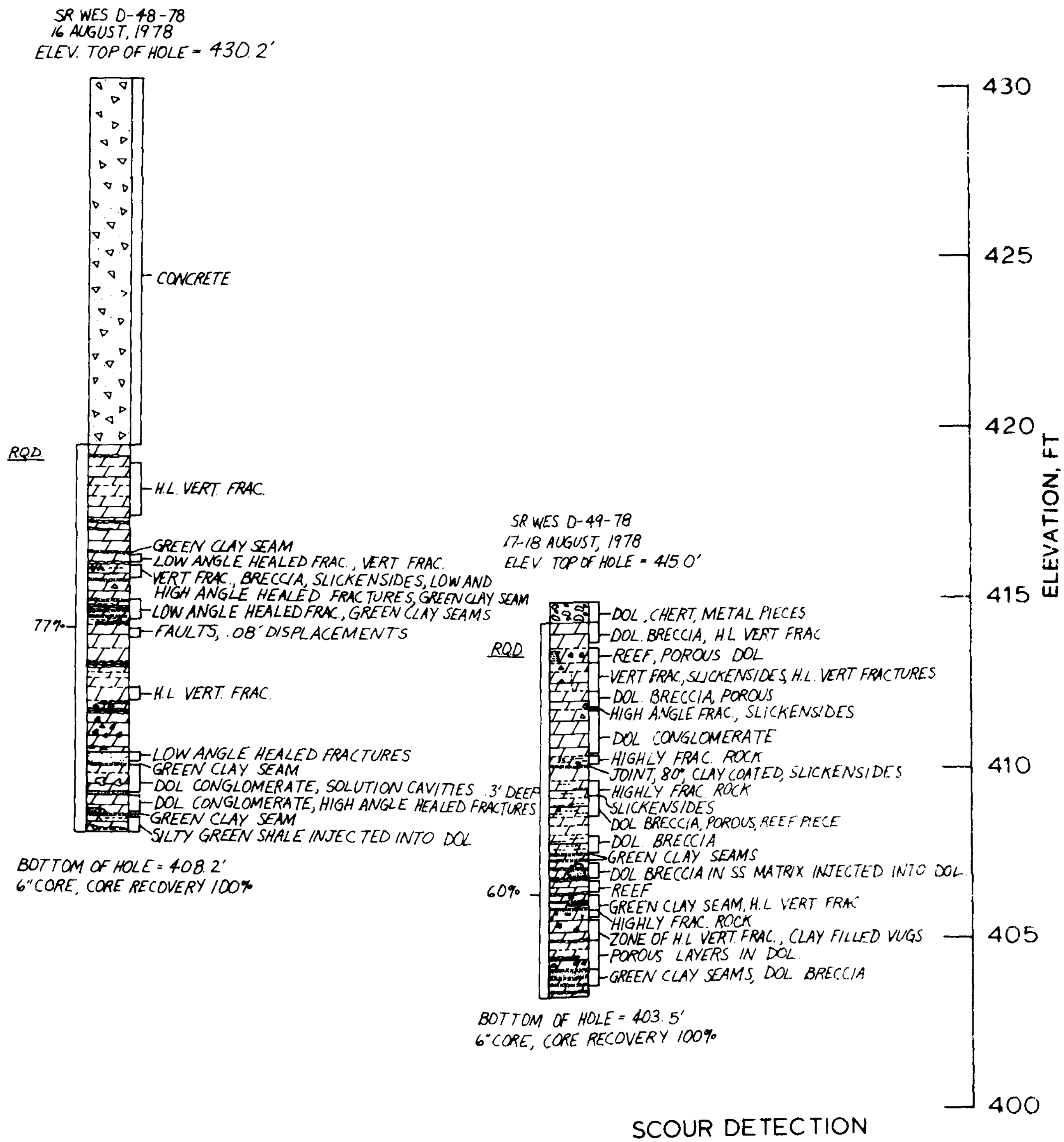
2



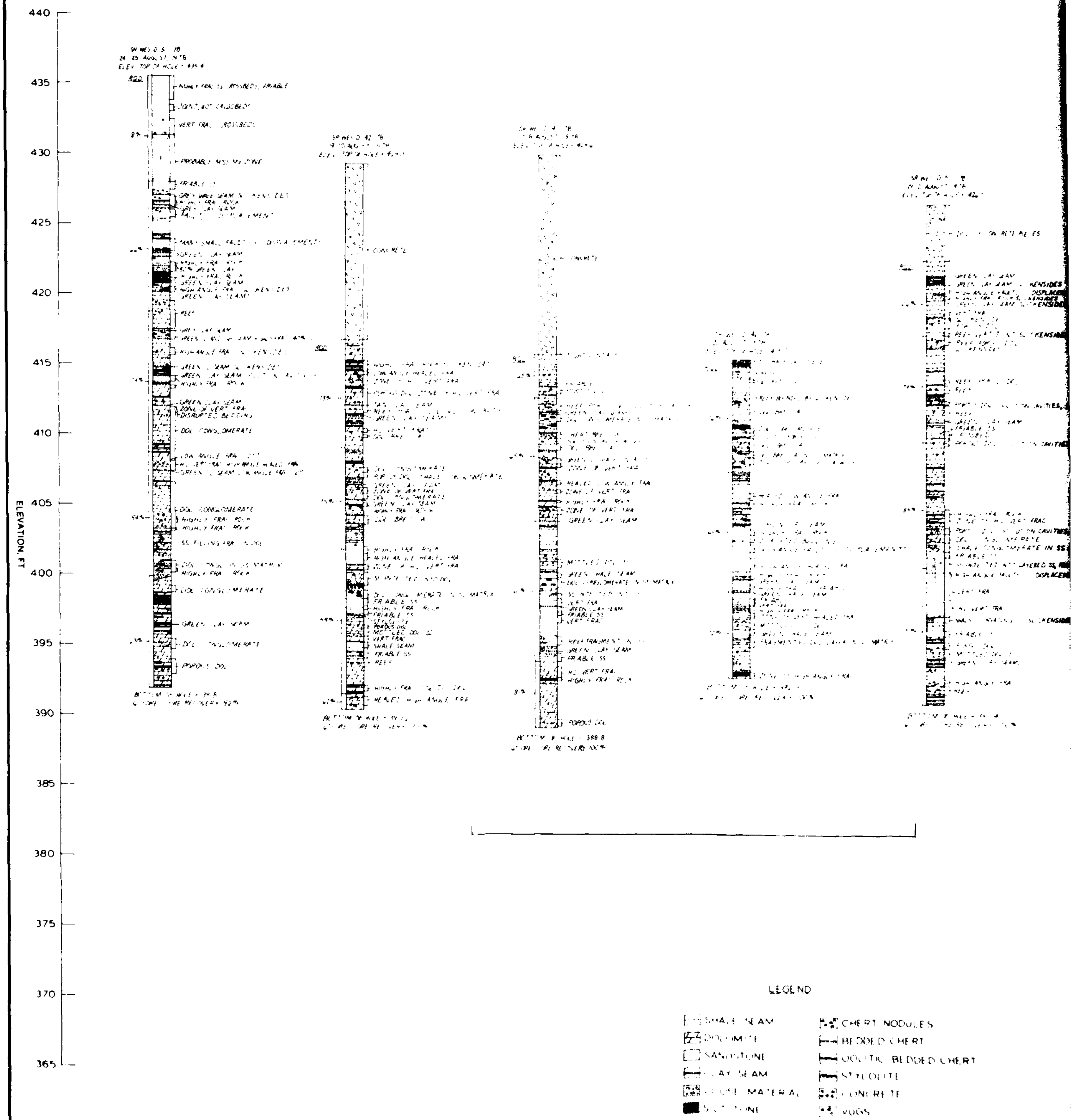
SR WES D-43-78
11 AUGUST, 1978
ELEV. TOP OF HOLE = 430.0'
ELEVATION, FT
430
425
420
415
410
405
400
CONCRETE
RQD
TIGHT CONTACT, GREEN SHALE SEAM
H.L. VERT FRAC
POROUS, FOSS. DOL FILLING SOLN. CAVITY IN DENSE DOL
DOL. CONGLOMERATE
HIGHLY FRAC. ROCK, GREEN CLAY SEAM
67%
DOL CONGLOMERATE
HIGHLY FRAC. ROCK, SLICKENSIDES
REEF, HEALED HIGH ANGLE FRAC.
DOL. CONGLOMERATE
JOINT, 45°
HEALED HIGH ANGLE FRACTURES
HIGH ANGLE FRAC.
DOL CONGL., REEF FRAGMENTS
DOL CONGLOMERATE
POROUS DOL., WHITE CLAY SEAM
REEF-LIKE CHERT BED
74%
HIGH ANGLE FRAC., SLICKENSIDES
DOL CONGLOMERATE
SLICKENSIDES
HIGHLY FRAC. ROCK, SLICKENSIDES
GREEN CLAY SEAM
LOW ANGLE FRAC.
BOTTOM OF HOLE = 406.7'
6" CORE, CORE RECOVERY 100%
SR WES D-44-78
11 AUGUST, 1978
ELEV. TOP OF HOLE = 420.6'
RQD
DOL, METAL PIECES
DOL CONGLOMERATE
SLICKENSIDES
79%
DOL CONGLOMERATE
HIGH ANGLE FRAC
DOL CONGLOMERATE, POROUS
DOL CONGLOMERATE
GREEN CLAY SEAM
HIGHLY FRAC. ROCK
REEF, POROUS DOL
WHITE SANDY CLAY SEAM
POROUS, HIGHLY FRAC. ROCK
BOTTOM OF HOLE = 411.9'
6" CORE, CORE RECOVERY 100%
LEGEND
SHALE SEAM
DOLOMITE
SANDSTONE
CLAY SEAM
LOOSE MATERIAL
SILTSTONE
CHERT N
BEDDED
OOLITIC
STYLOLI
CONCRE
VUGS


SR WES D-45-78
14 AUGUST, 1978
ELEV. TOP OF HOLE = 418.5'
RQD
56%
DOL., CHERT PIECES
DOL CONGLOMERATE
HIGHLY FRAC. ROCK
JOINT, 30°
HIGHLY FRAC. ROCK
DOL. BRECCIA
GREEN CLAY SEAM
DOL CONGLOMERATE
DOL CONGLOMERATE, HEALED LOW ANGLE FRAC.
HIGHLY FRAC. ROCK
DOL. CONGLOMERATE
GREEN CLAY SEAM
POROUS DOL
GREEN CLAY SEAM
OPEN VERT FRAC
HIGHLY FRAC. ROCK
BOTTOM OF HOLE = 409.2'
6" CORE, CORE RECOVERY 100%
SR WES D-47-78
15 AUGUST, 1978
ELEV. TOP OF HOLE = 419.9'
RQD
63%
DOL BRECCIA
DISRUPTED BEDDING
GREEN CLAY SEAM
DOL CONGLOMERATE
WHITE CLAY SEAM
GREEN CLAY SEAMS
HIGHLY FRAC. ROCK
POROUS DOL., H.L. VERT FRACTURES
GREEN CLAY SEAM
DOL CONGLOMERATE
HEALED LOW ANGLE FRACTURES
GREEN CLAY SEAMS
DOL. CONGLOMERATE
GREEN CLAY SEAM
HIGHLY FRAC. ROCK, SLICKENSIDES
HIGHLY FRAC. ROCK
HIGHLY FRAC. ROCK
BOTTOM OF HOLE = 407.7'
6" CORE, CORE RECOVERY 100%
SR WES D-48-78
16 AUGUST, 1978
ELEV. TOP OF HOLE =
RQD
77%
H.L. VER
GREEN
LOW AN
VERT FR
HIGH AN
LOW AN
FAULT
H.L. VER
LOW A
GREEN
DOL. CO
DOL. CO
GREEN
SILTY C
BOTTOM OF HOLE = 408.
6" CORE, CORE RECOVERY
ROUS
RT NODULES
DED CHERT
BEDDED CHERT

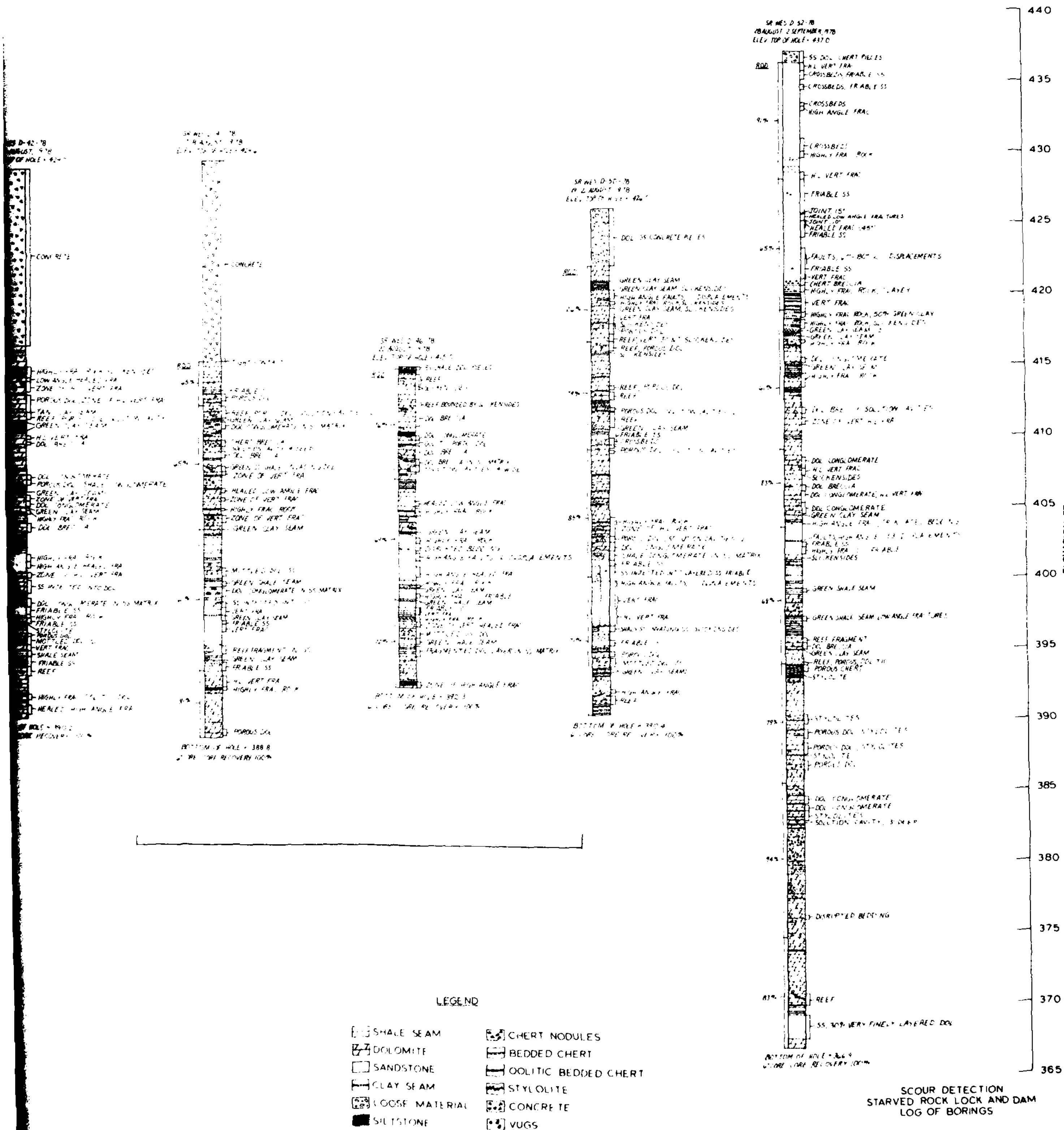
2



SCOUR DETECTION
STARVED ROCK LOCK AND DAM
LOG OF BORINGS



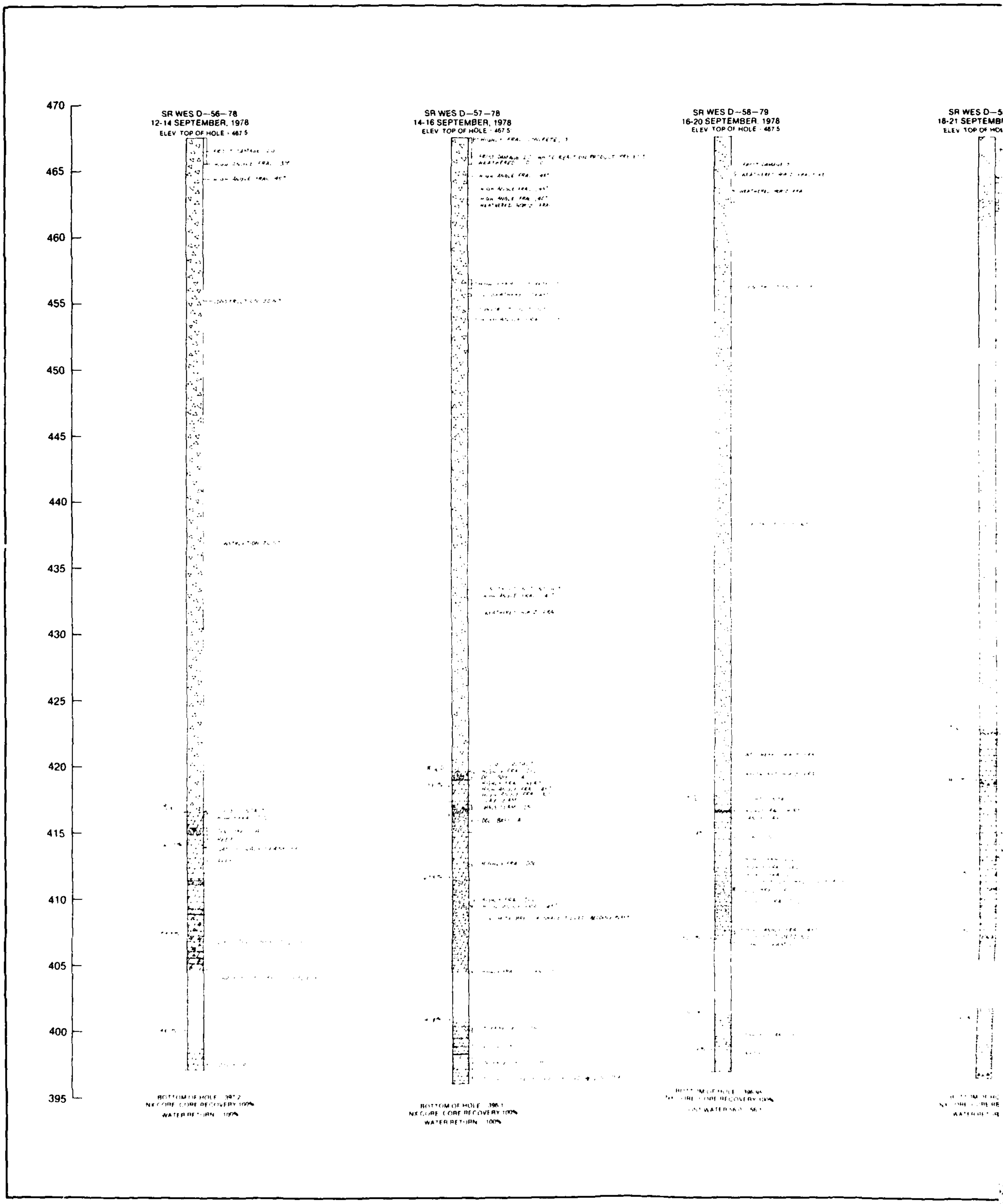
440
435
430
425
420
415
410
405
400
395
390
385
380
375
370
365
ELEVATION, FT
LEGEND
CHERT NODULES
BEDDED CHERT
OOLITIC BEDDED CHERT
CONCRETE
VUGS



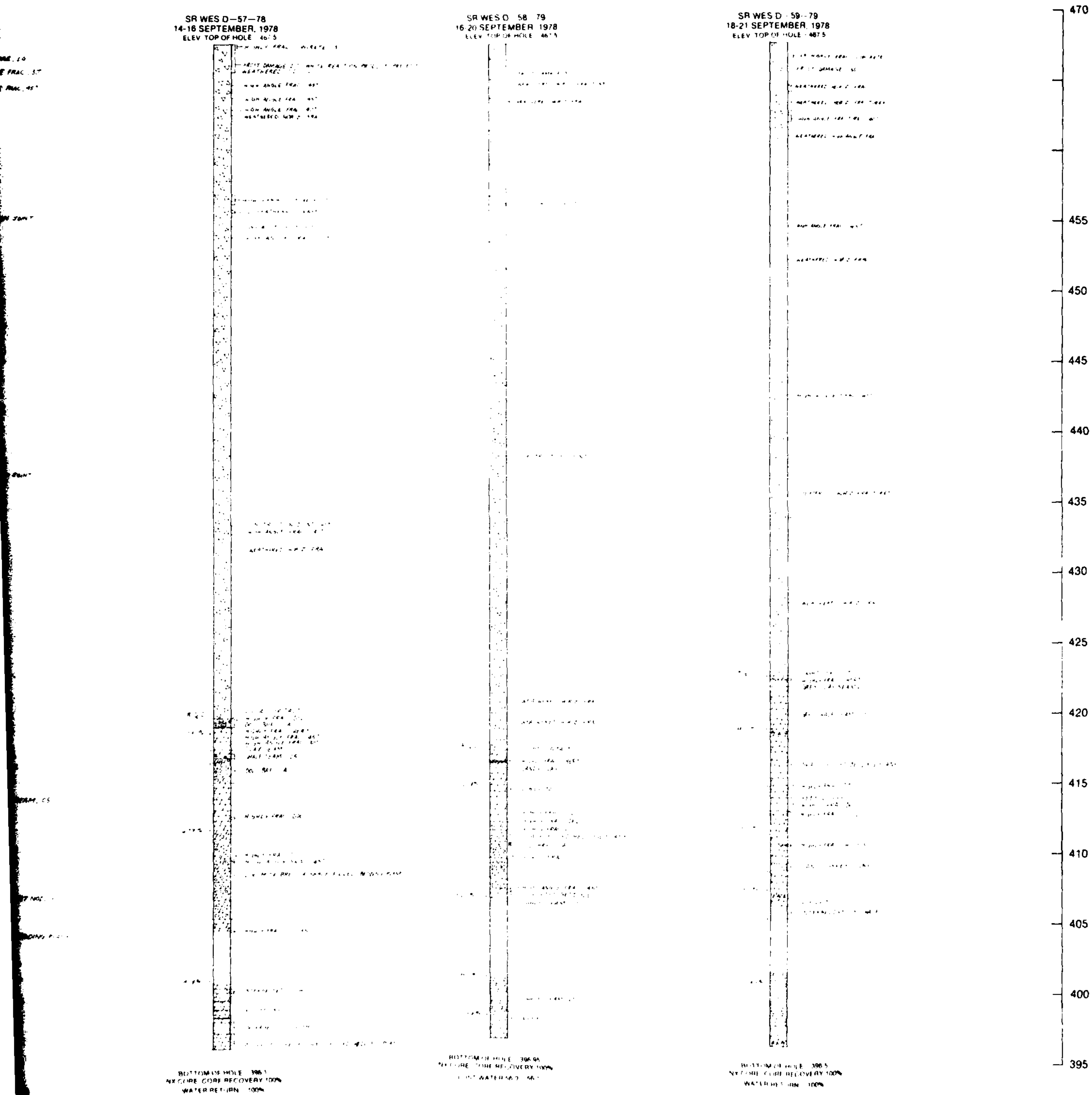
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
LOG OF BORINGS

PLATE 7a

2



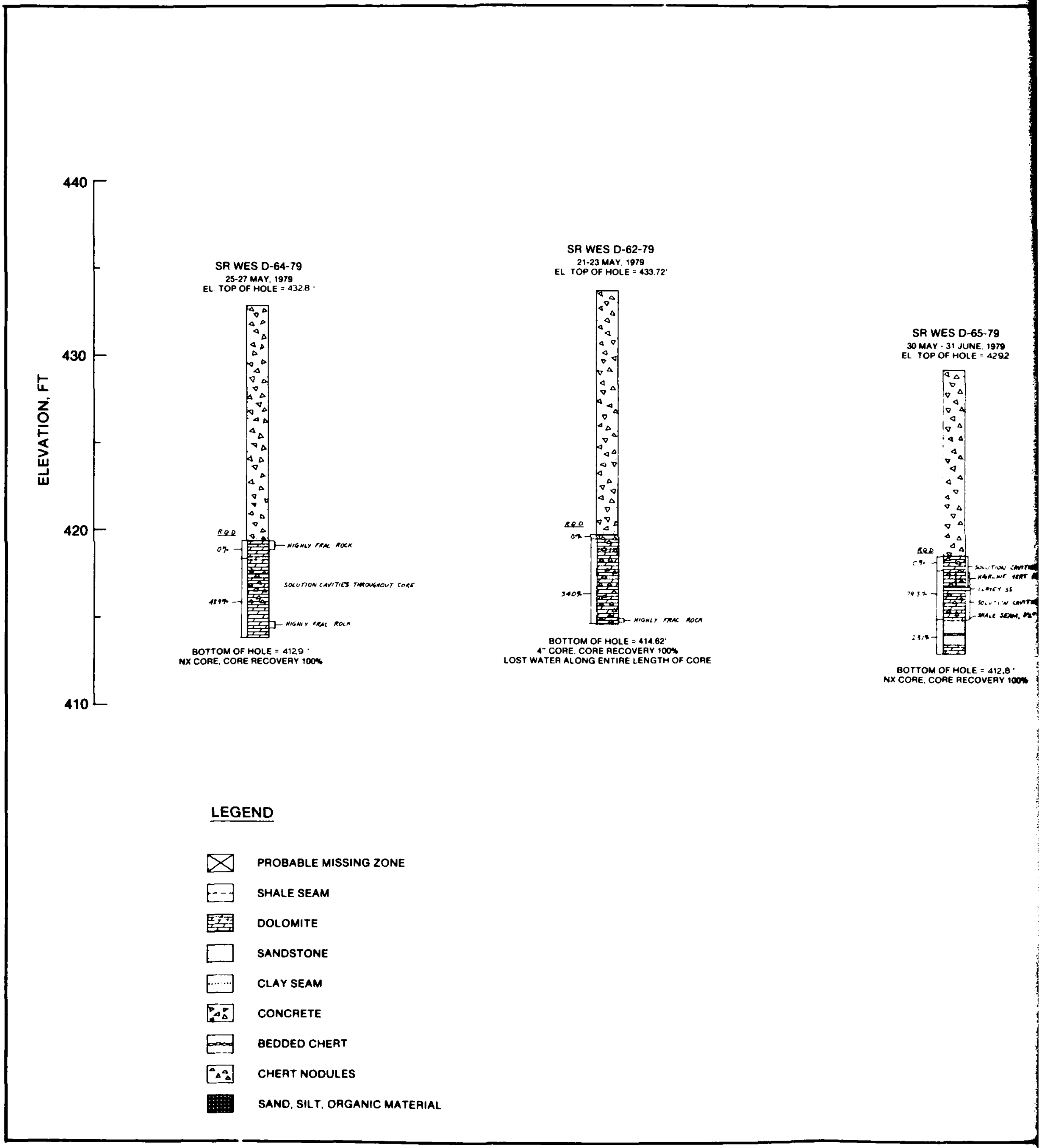
470
465
460
455
450
445
440
435
430
425
420
415
410
405
400
395
SR WES D—56—78
12-14 SEPTEMBER, 1978
SR WES D—57—78
14-16 SEPTEMBER, 1978
SR WES D—58—79
16-20 SEPTEMBER, 1978
NX CORE CORE RECOVERY 100%
WATER RETURN 100%



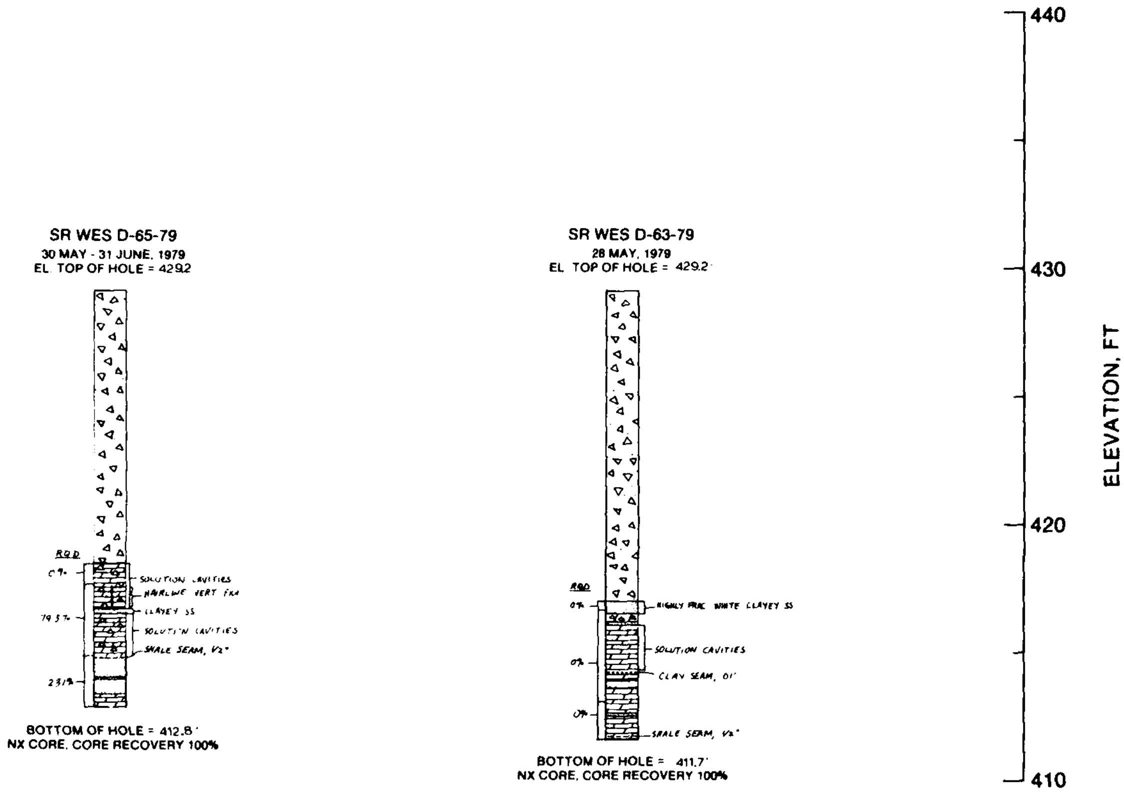
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
LOG OF BORINGS

PLATE 7b

2



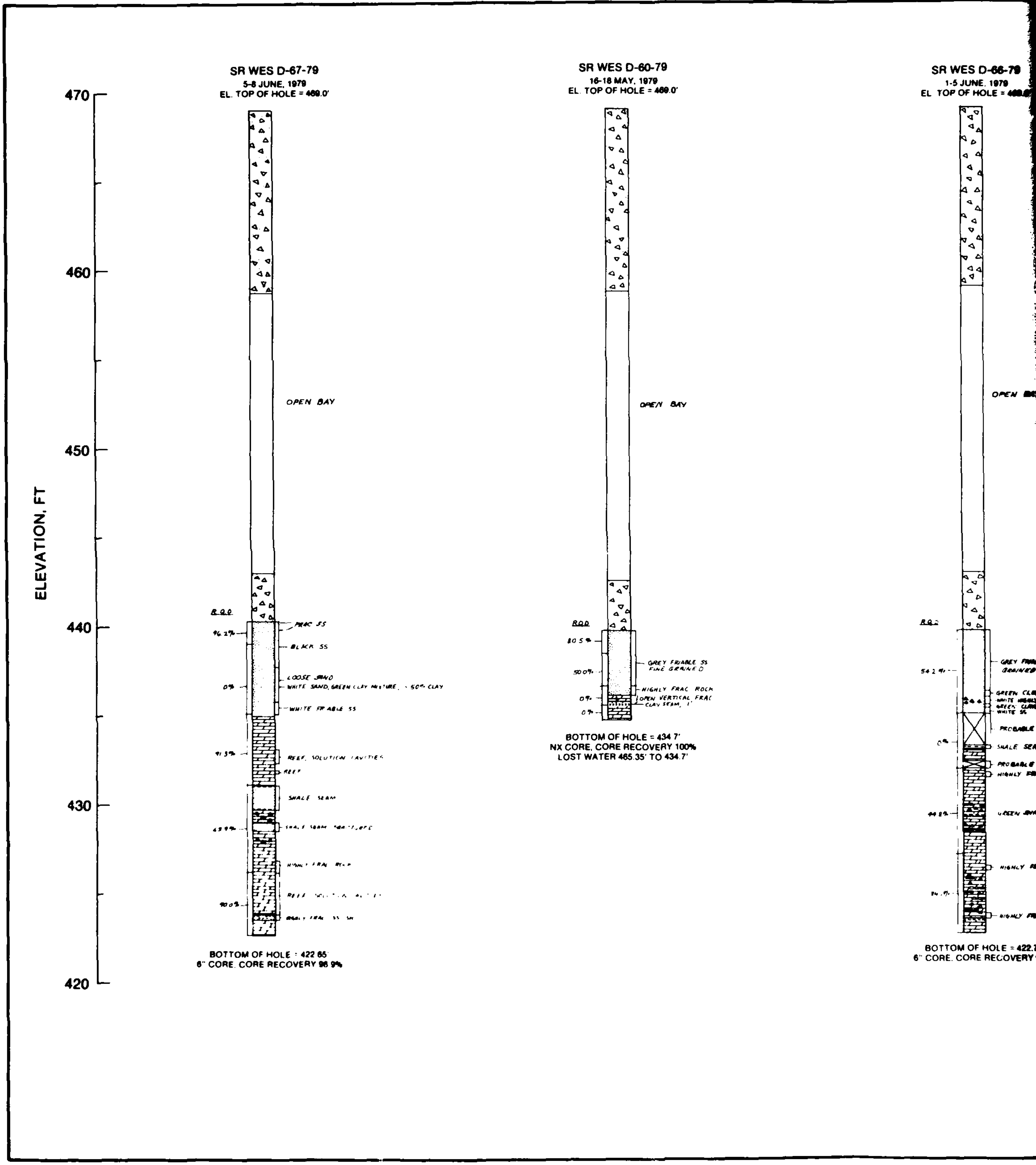
440
430
420
410
ELEVATION, FT
SR WES D-64-79
25-27 MAY, 1979
EL TOP OF HOLE = 432.8 '
RQD
0%
48.9%
HIGHLY FRAC ROCK
SOLUTION CAVITIES THROUGHOUT CORE
HIGHLY FRAC ROCK
BOTTOM OF HOLE = 412.9 '
NX CORE, CORE RECOVERY 100%
SR WES D-62-79
21-23 MAY, 1979
EL TOP OF HOLE = 433.72'
RQD
0%
34.0%
HIGHLY FRAC ROCK
BOTTOM OF HOLE = 414.62'
4" CORE, CORE RECOVERY 100%
LOST WATER ALONG ENTIRE LENGTH OF CORE
SR WES D-65-79
30 MAY - 31 JUNE, 1979
EL TOP OF HOLE = 429.2
RQD
0%
BOTTOM OF HOLE = 412.8 '
NX CORE, CORE RECOVERY 100%
LEGEND
PROBABLE MISSING ZONE
SHALE SEAM
DOLOMITE
SANDSTONE
CLAY SEAM
CONCRETE
BEDDED CHERT
CHERT NODULES
SAND, SILT, ORGANIC MATERIAL



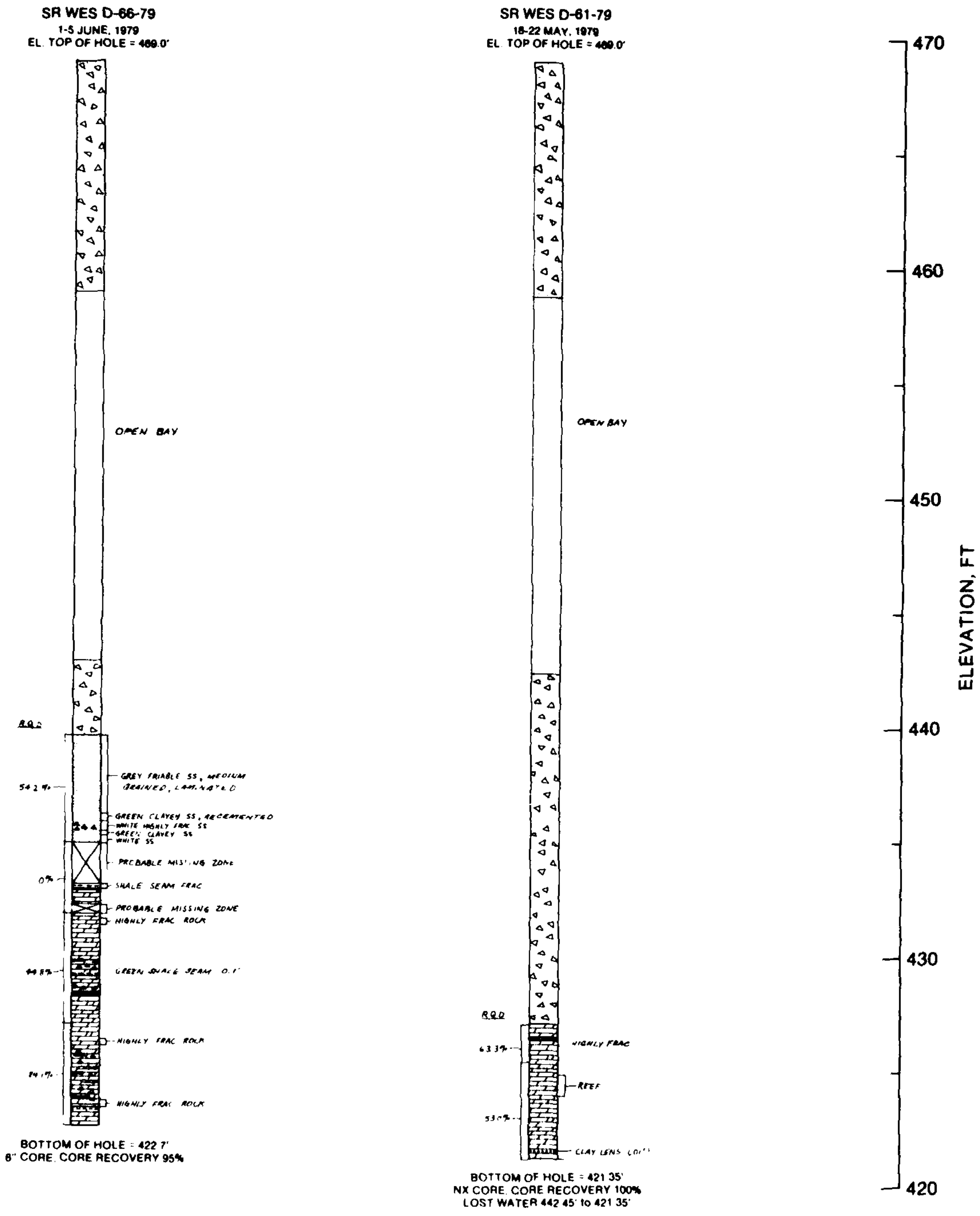
MAJOR REHABILITATION, ADDITIONAL BORINGS
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
LOG OF BORINGS

PLATE 7c

2



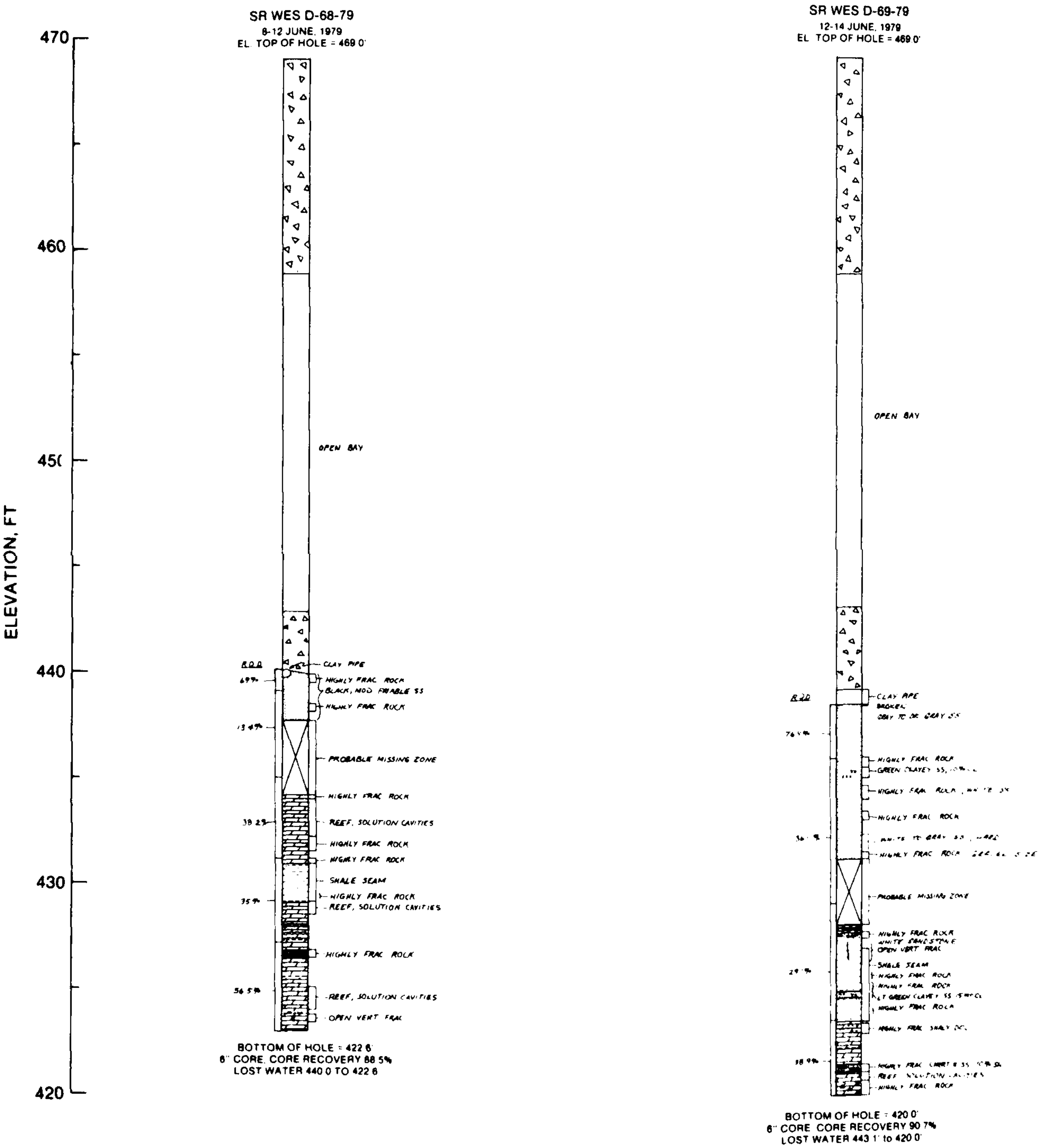
ELEVATION, FT
470
460
450
440
430
420
SR WES D-67-79
5-8 JUNE, 1979
EL. TOP OF HOLE = 469.0'
OPEN BAY
R.Q.D.
96.2%
0%
91.3%
43.9%
90.0%
FRAC SS
BLACK SS
LOOSE SAND
WHITE SAND, GREEN CLAY MIXTURE, < 50% CLAY
WHITE FRIABLE SS
REEF, SOLUTION CAVITIES
REEF
SHALE SEAM
BOTTOM OF HOLE = 422.65'
6" CORE, CORE RECOVERY 96.9%
SR WES D-60-79
16-18 MAY, 1979
EL. TOP OF HOLE = 469.0'
OPEN BAY
RQD
80.5%
50.0%
0%
0%
GREY FRIABLE SS
FINE GRAINED
HIGHLY FRAC ROCK
OPEN VERTICAL FRAC
CLAY SEAM, 1'
BOTTOM OF HOLE = 434.7'
NX CORE, CORE RECOVERY 100%
LOST WATER 465.35' TO 434.7'
SR WES D-66-79
1-5 JUNE, 1979
EL. TOP OF HOLE =
OPEN
RQD
0%
SHALE SEAM
HIGHLY
BOTTOM OF HOLE = 422.7'
6" CORE, CORE RECOVERY

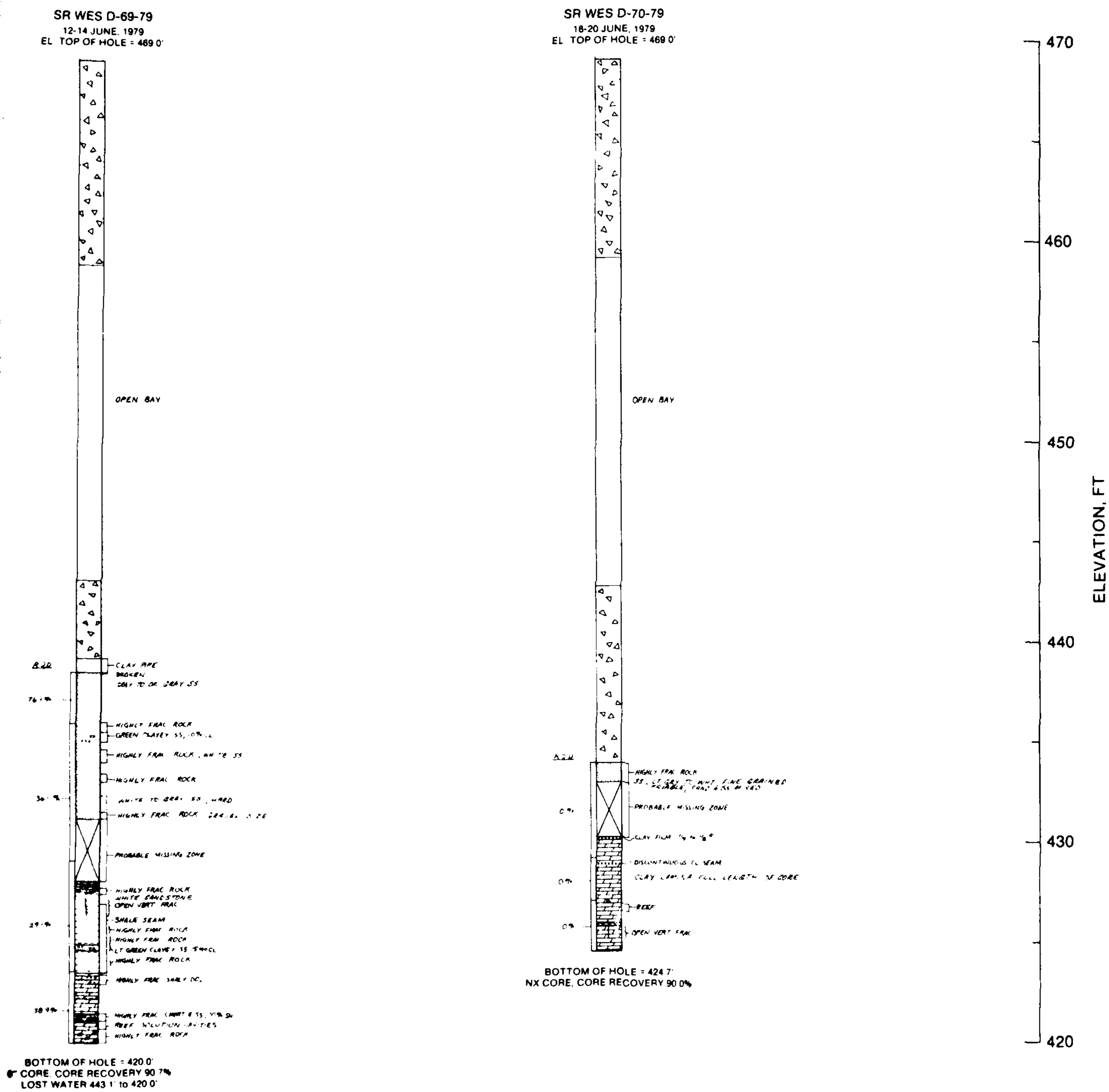


MAJOR REHABILITATION, ADDITIONAL BORINGS
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
LOG OF BORINGS

PLATE 7d

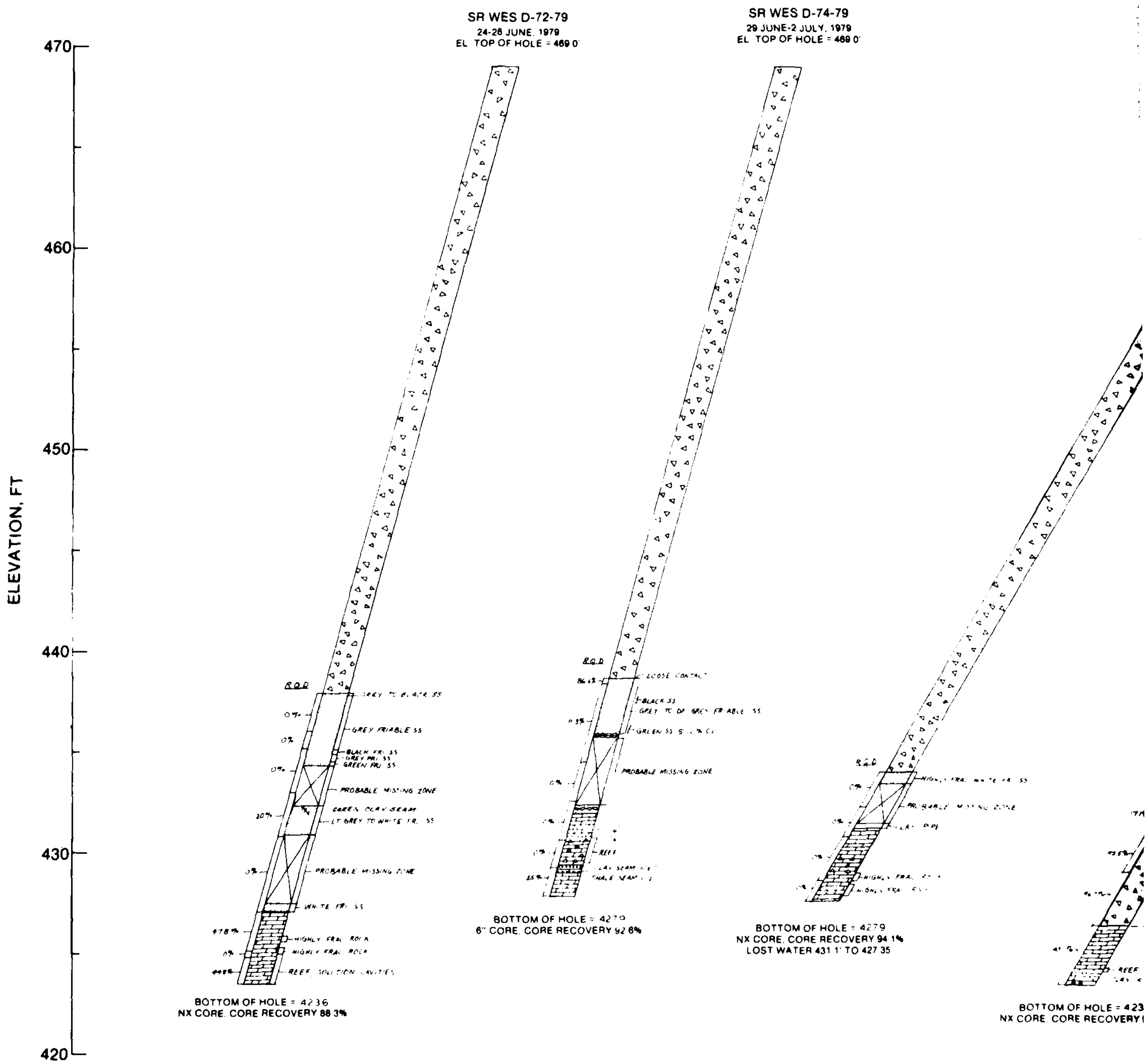
2


ELEVATION, FT
470
460
45(
440
430
420
SR WES D-68-79
8-12 JUNE, 1979
EL. TOP OF HOLE = 469.0'
OPEN BAY
RQD
CLAY PIPE
69%
HIGHLY FRAC ROCK
BLACK, MOD FRIABLE SS
HIGHLY FRAC ROCK
13.4%
PROBABLE MISSING ZONE
HIGHLY FRAC ROCK
38.2%
REEF, SOLUTION CAVITIES
HIGHLY FRAC ROCK
HIGHLY FRAC ROCK
SHALE SEAM
35%
HIGHLY FRAC ROCK
REEF, SOLUTION CAVITIES
HIGHLY FRAC ROCK
56.5%
REEF, SOLUTION CAVITIES
OPEN VERT FRAC
BOTTOM OF HOLE = 422.6'
6" CORE. CORE RECOVERY 88.5%
LOST WATER 440.0 TO 422.6
SR WES D-69-79
12-14 JUNE, 1979
EL. TOP OF HOLE = 469.0'
OPEN BAY
RQD
CLAY PIPE
BROKEN
GRAY TO DK GRAY SS
HIGHLY FRAC ROCK
PROBABLE MISSING ZONE
HIGHLY FRAC ROCK
WHITE SANDSTONE
OPEN VERT FRAC
SHALE SEAM
HIGHLY FRAC ROCK
HIGHLY FRAC ROCK
HIGHLY FRAC ROCK
REEF, SOLUTION CAVITIES
HIGHLY FRAC ROCK
BOTTOM OF HOLE = 420.0'
6" CORE. CORE RECOVERY 90.7%
LOST WATER 443.1' to 420.0'

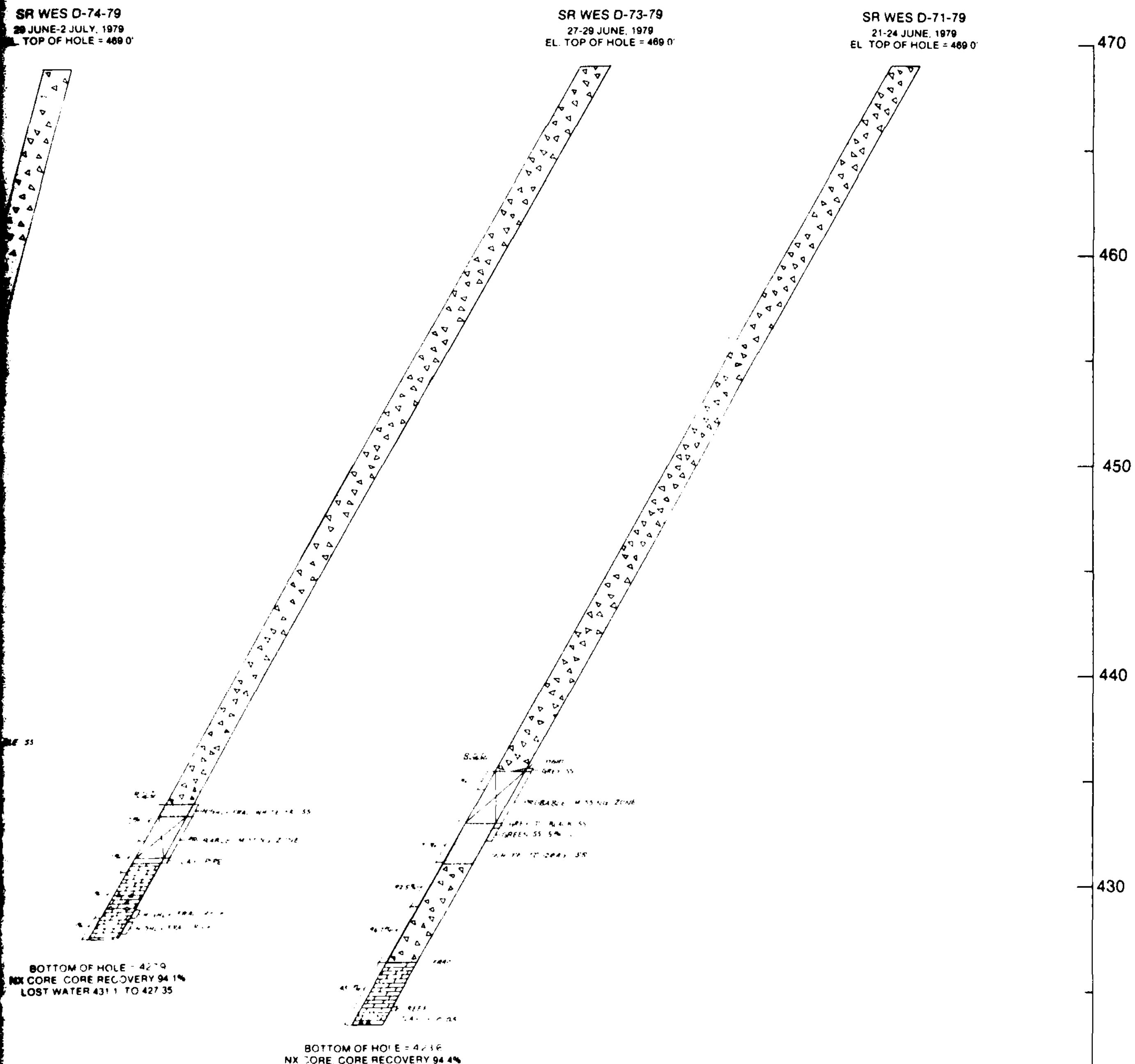


MAJOR REHABILITATION. ADDITIONAL BORINGS
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

LOG OF BORINGS



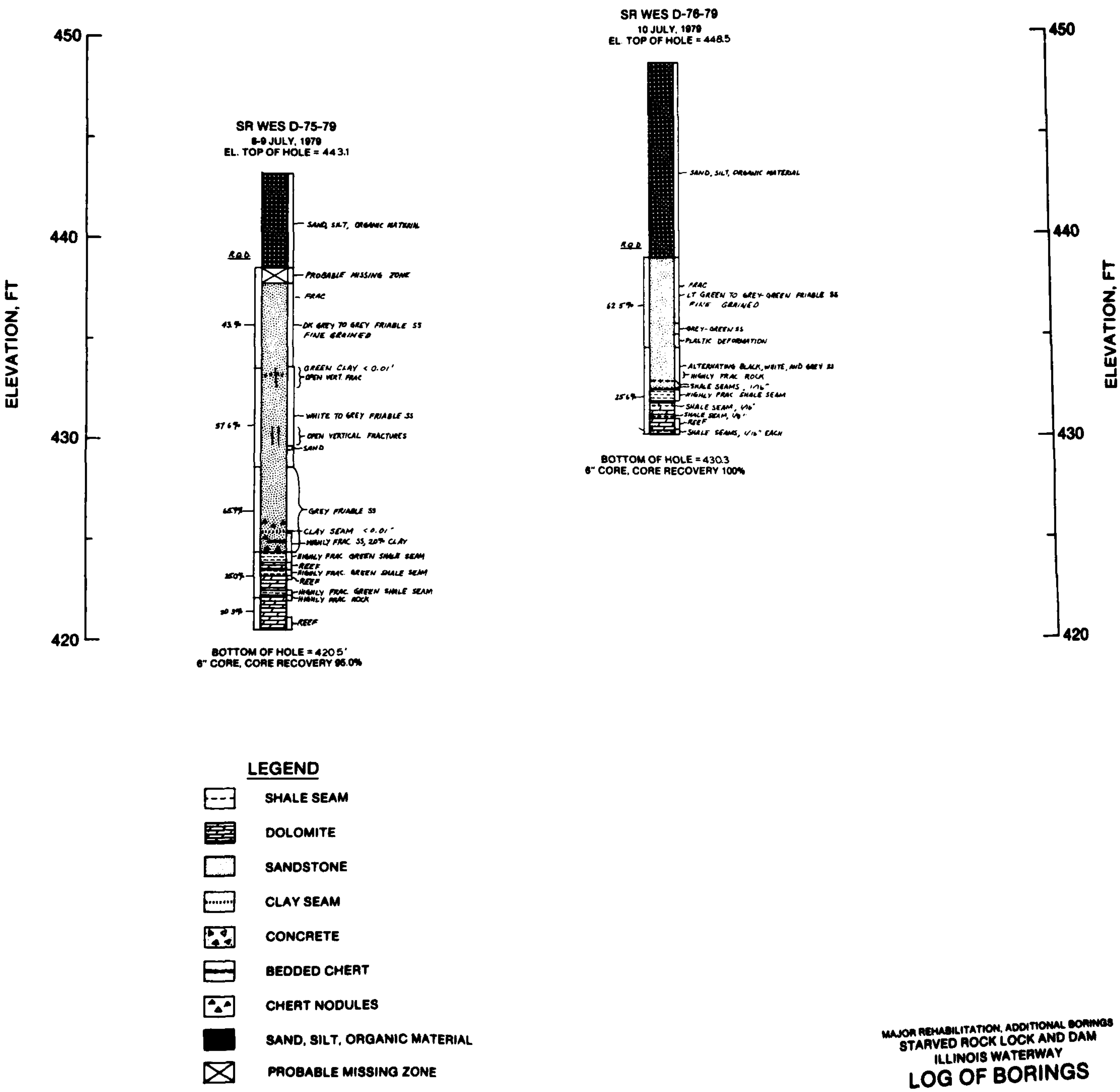
ELEVATION, FT
470
460
450
440
430
420
SR WES D-72-79
24-28 JUNE, 1979
EL TOP OF HOLE = 469 0'
R.Q.D.
GREY FRIABLE SS
BLACK FRI SS
GREY FRI SS
GREEN FRI SS
PROBABLE MISSING ZONE
GREEN CLAY SEAM
LT GREY TO WHITE FRI SS
PROBABLE MISSING ZONE
WHITE FRI SS
HIGHLY FRAC ROCK
HIGHLY FRAC ROCK
REEF, SOLUTION CAVITIES
BOTTOM OF HOLE = 423 6
NX CORE, CORE RECOVERY 88 3%
SR WES D-74-79
29 JUNE-2 JULY, 1979
EL TOP OF HOLE = 469 0'
R.Q.D.
LOOSE CONTACT
BLACK SS
PROBABLE MISSING ZONE
REEF
BOTTOM OF HOLE = 427 9
6" CORE, CORE RECOVERY 92 6%
R.Q.D.
PROBABLE MISSING ZONE
BOTTOM OF HOLE = 427 9
NX CORE, CORE RECOVERY 94 1%
LOST WATER 431 1' TO 427 35



MAJOR REHABILITATION, ADDITIONAL BORINGS
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
LOG OF BORINGS

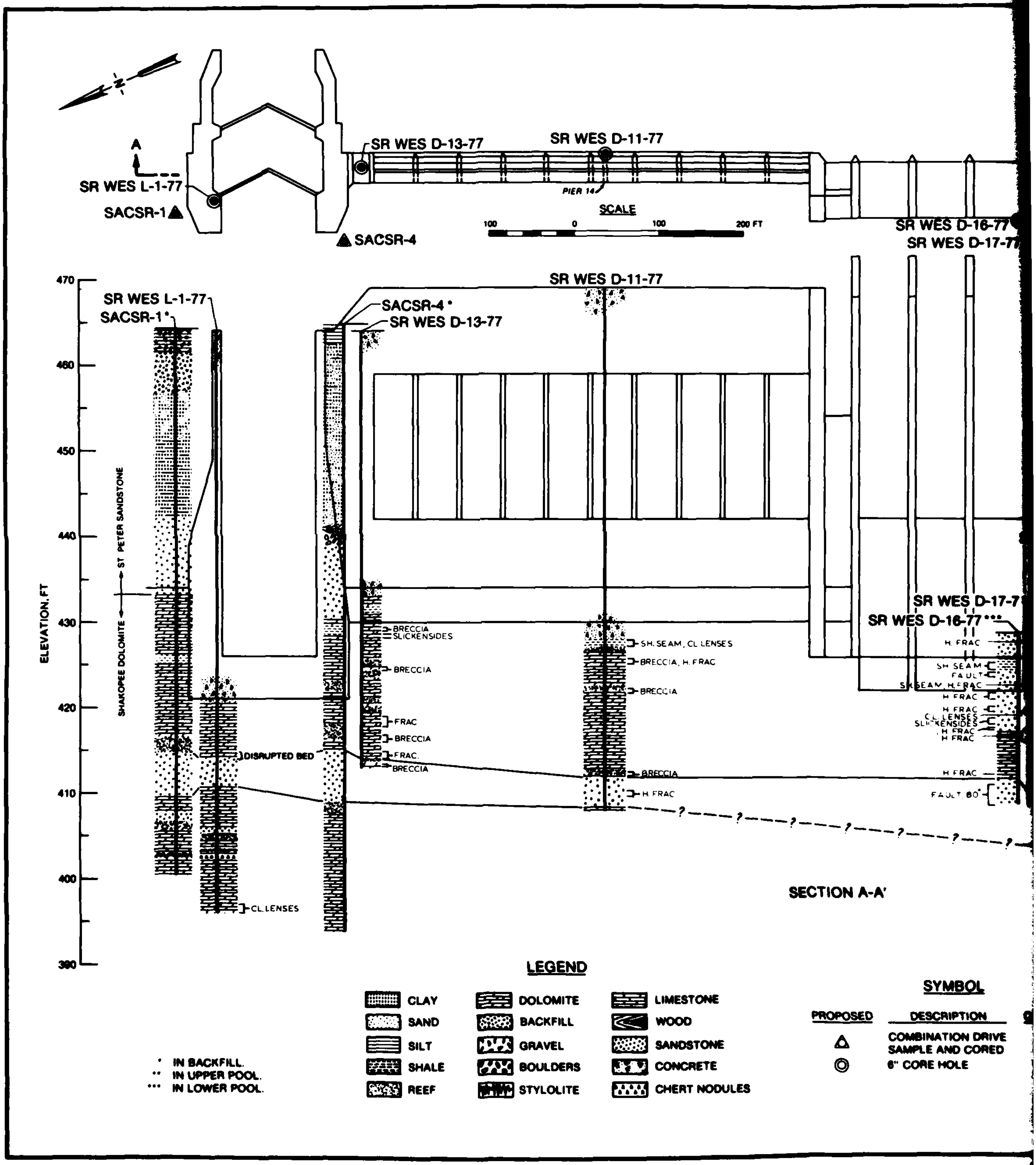
AD-A085 584 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/13
CONCRETE AND ROCK TESTS, MAJOR REHABILITATION OF STARVED ROCK L--ETC(U)
APR 80 R L STOWE, B A PAVLOV
UNCLASSIFIED WES/MP/SL-80-6 NL

2 OF 3
AD A
085584

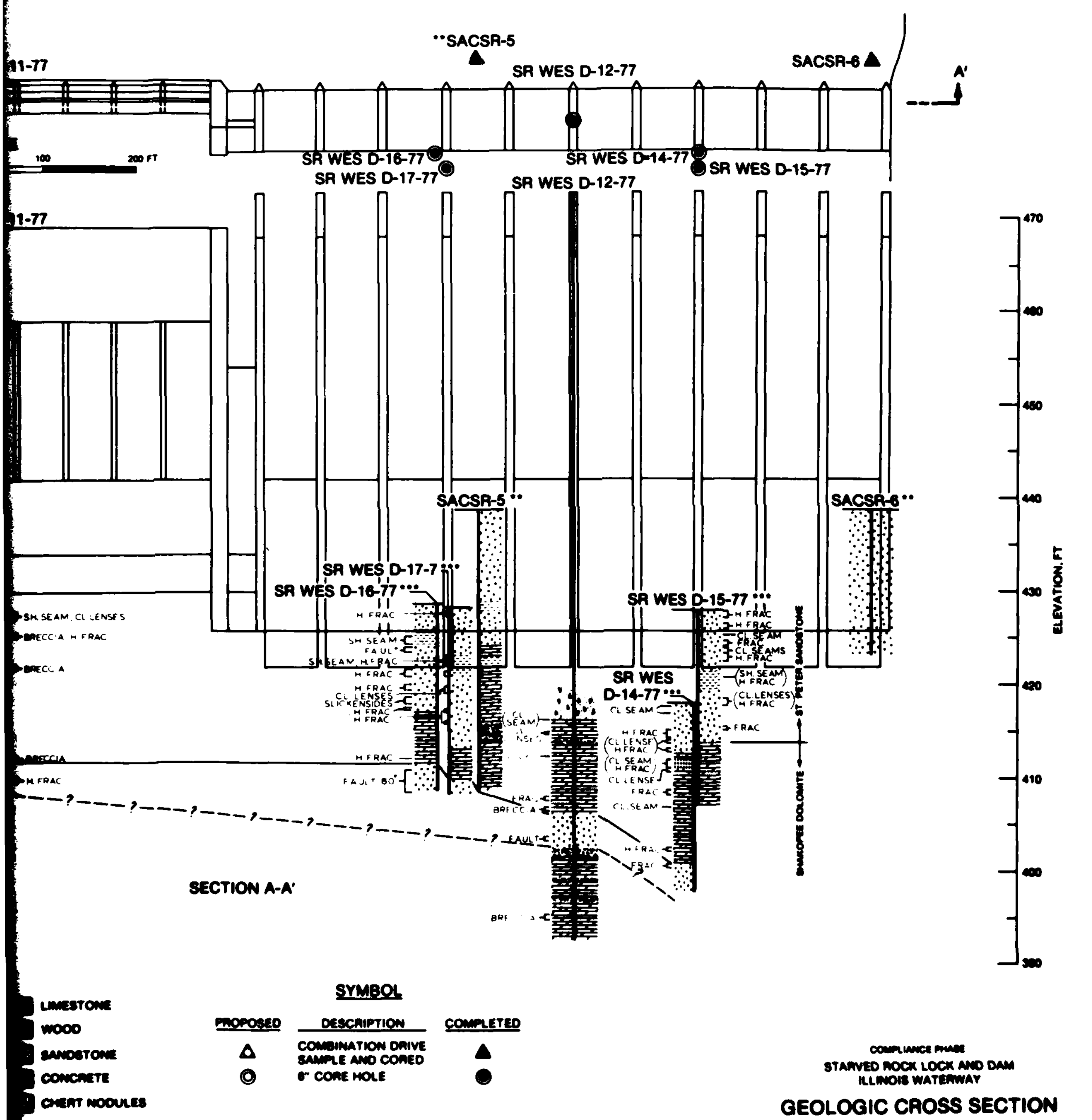


MAJOR REHABILITATION, ADDITIONAL BORINGS
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

LOG OF BORINGS



SR WES D-13-77
SR WES D-11-77
A
SR WES L-1-77
SACSR-1
SACSR-4
PIER 14
SCALE
100
0
100
200 FT
SR WES D-16-77
SR WES D-17-77
ELEVATION, FT
470
460
450
440
430
420
410
400
390
SR WES L-1-77
SACSR-1 *
SACSR-4 *
SR WES D-13-77
SR WES D-11-77
ST PETER SANDSTONE
SHAKOPEE DOLOMITE
BRECCIA
SLICKENSIDES
BRECCIA
FRAC
BRECCIA
FRAC.
BRECCIA
DISRUPTED BED
CL. LENSES
SH. SEAM, CL LENSES
BRECCIA, H. FRAC
BRECCIA
BRECCIA
H. FRAC
SR WES D-17-77
SR WES D-16-77 ***
H. FRAC
SH. SEAM
FAULT
SH. SEAM, H. FRAC
H. FRAC
H. FRAC
CL. LENSES
SLICKENSIDES
H. FRAC
H. FRAC
H. FRAC
FAULT 80°
SECTION A-A'
LEGEND
CLAY
SAND
SILT
SHALE
REEF
DOLOMITE
BACKFILL
GRAVEL
BOULDERS
STYLOLITE
LIMESTONE
WOOD
SANDSTONE
CONCRETE
CHERT NODULES
SYMBOL
PROPOSED
DESCRIPTION
COMBINATION DRIVE SAMPLE AND CORED
6" CORE HOLE
* IN BACKFILL.
** IN UPPER POOL.
*** IN LOWER POOL.

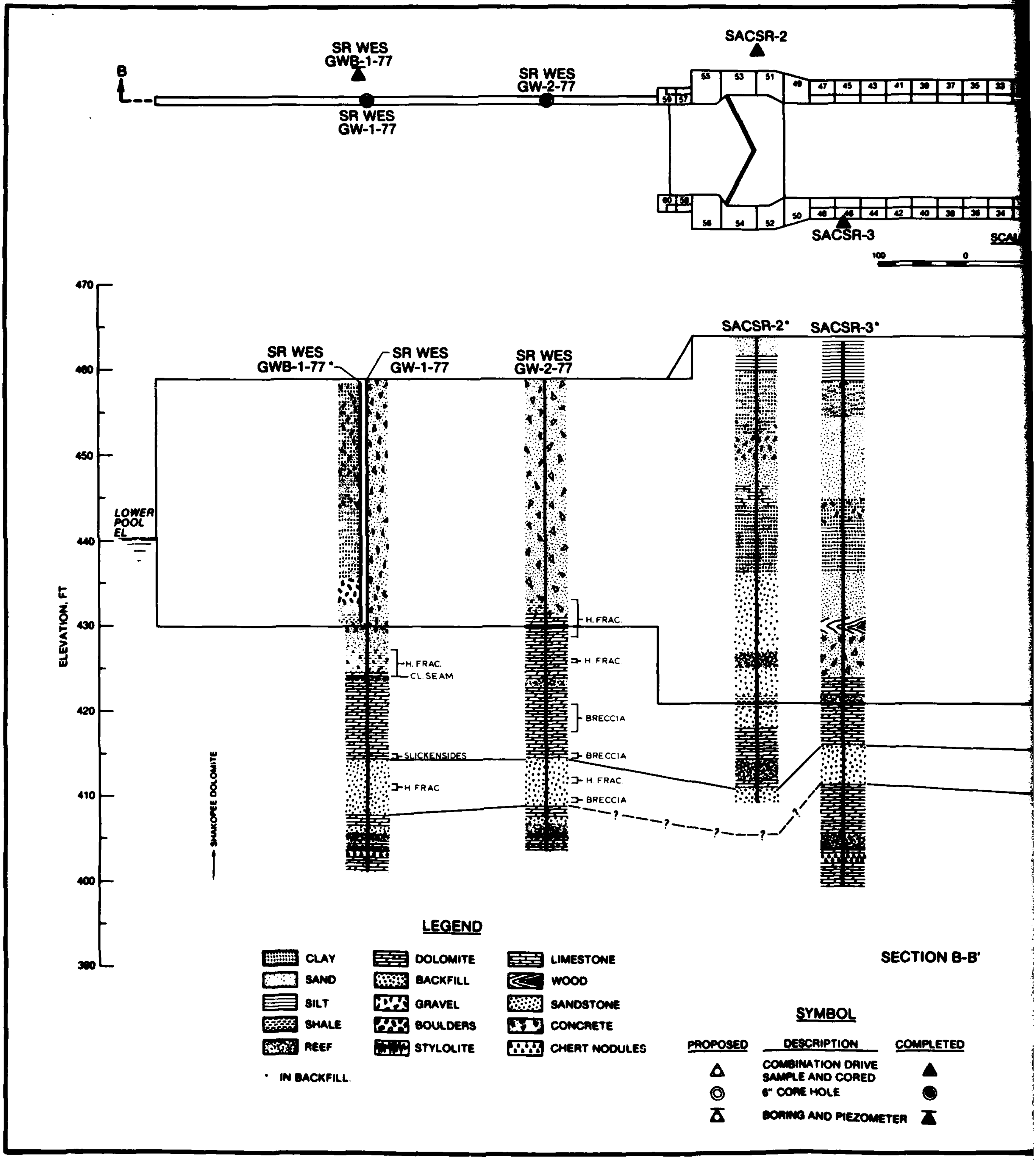


COMPLIANCE PHASE
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

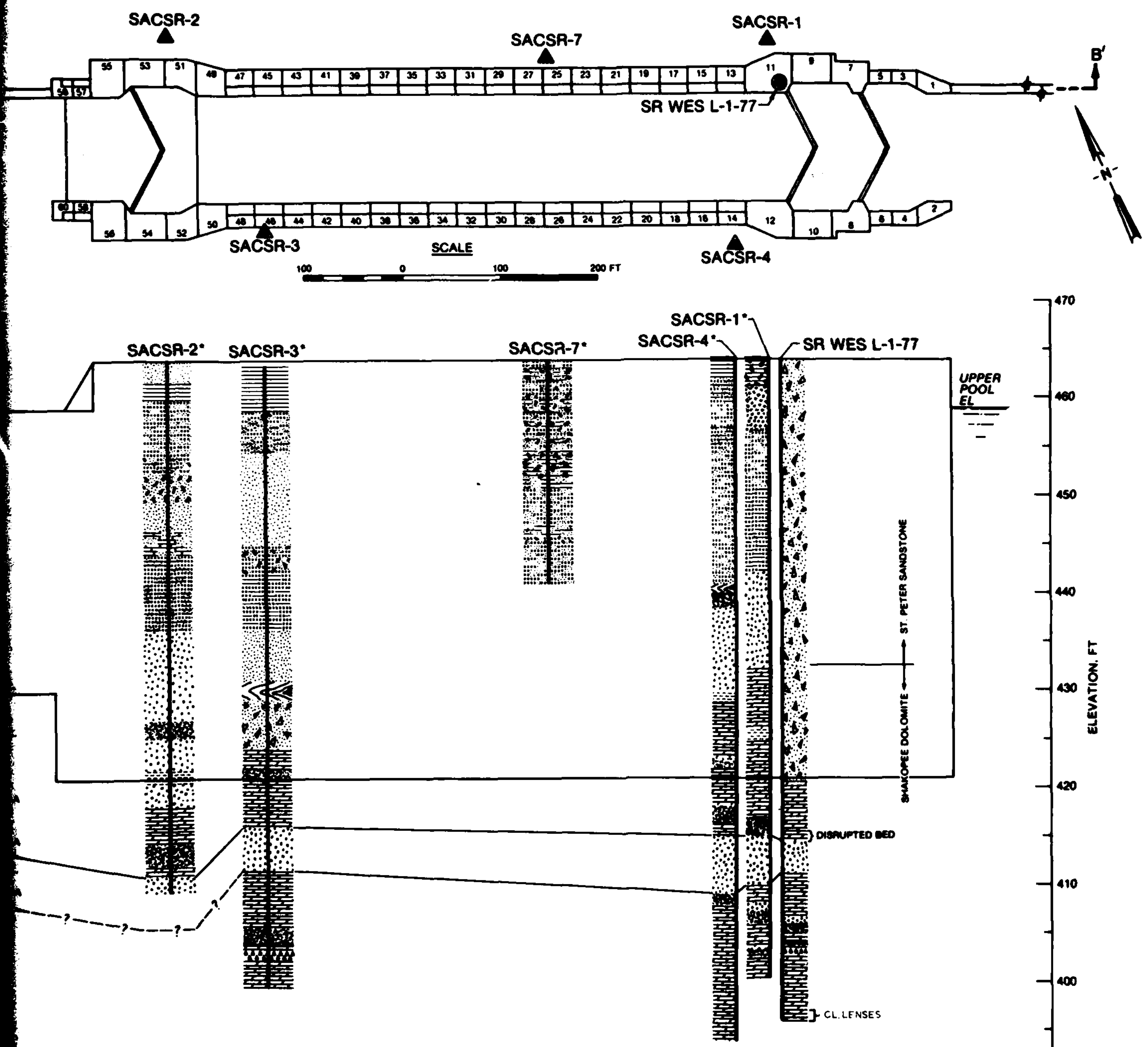
GEOLOGIC CROSS SECTION
SECTION A-A'

PLATE 8

2



B
SR WES
GWB-1-77
SR WES
GW-1-77
SR WES
GW-2-77
SACSR-2
SACSR-3
55
53
51
49
47
45
43
41
39
37
35
33
59
57
60
58
56
54
52
50
48
46
44
42
40
38
36
34
SCAL
100
0
470
460
450
440
430
420
410
400
390
ELEVATION, FT
LOWER POOL EL
SR WES GWB-1-77 *
SR WES GW-1-77
SR WES GW-2-77
SACSR-2*
SACSR-3*
H. FRAC.
CL. SEAM
SLICKENSIDES
H. FRAC
H. FRAC.
H. FRAC.
BRECCIA
BRECCIA
H. FRAC.
BRECCIA
SHAKOPEE DOLOMITE
LEGEND
CLAY
SAND
SILT
SHALE
REEF
DOLOMITE
BACKFILL
GRAVEL
BOULDERS
STYLOLITE
LIMESTONE
WOOD
SANDSTONE
CONCRETE
CHERT NODULES
* IN BACKFILL.
SECTION B-B'
SYMBOL
PROPOSED
DESCRIPTION
COMPLETED
COMBINATION DRIVE SAMPLE AND CORED
6" CORE HOLE
BORING AND PIEZOMETER



SECTION B-B'

SYMBOL

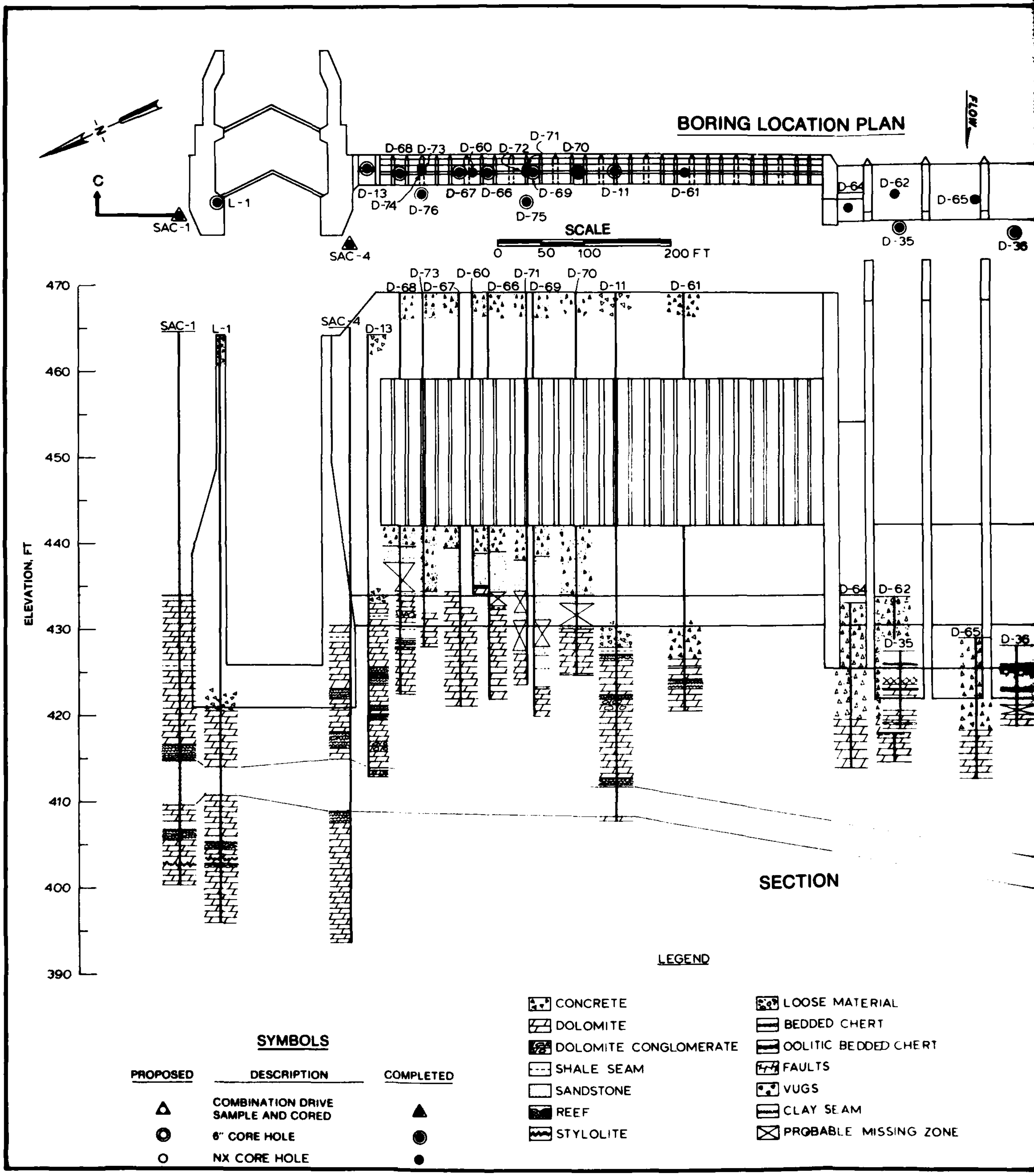
PROPOSED	DESCRIPTION	COMPLETED
△	COMBINATION DRIVE SAMPLE AND CORED	▲
◎	6" CORE HOLE	●
⧗	BORING AND PIEZOMETER	⧗

COMPLIANCE PHASE

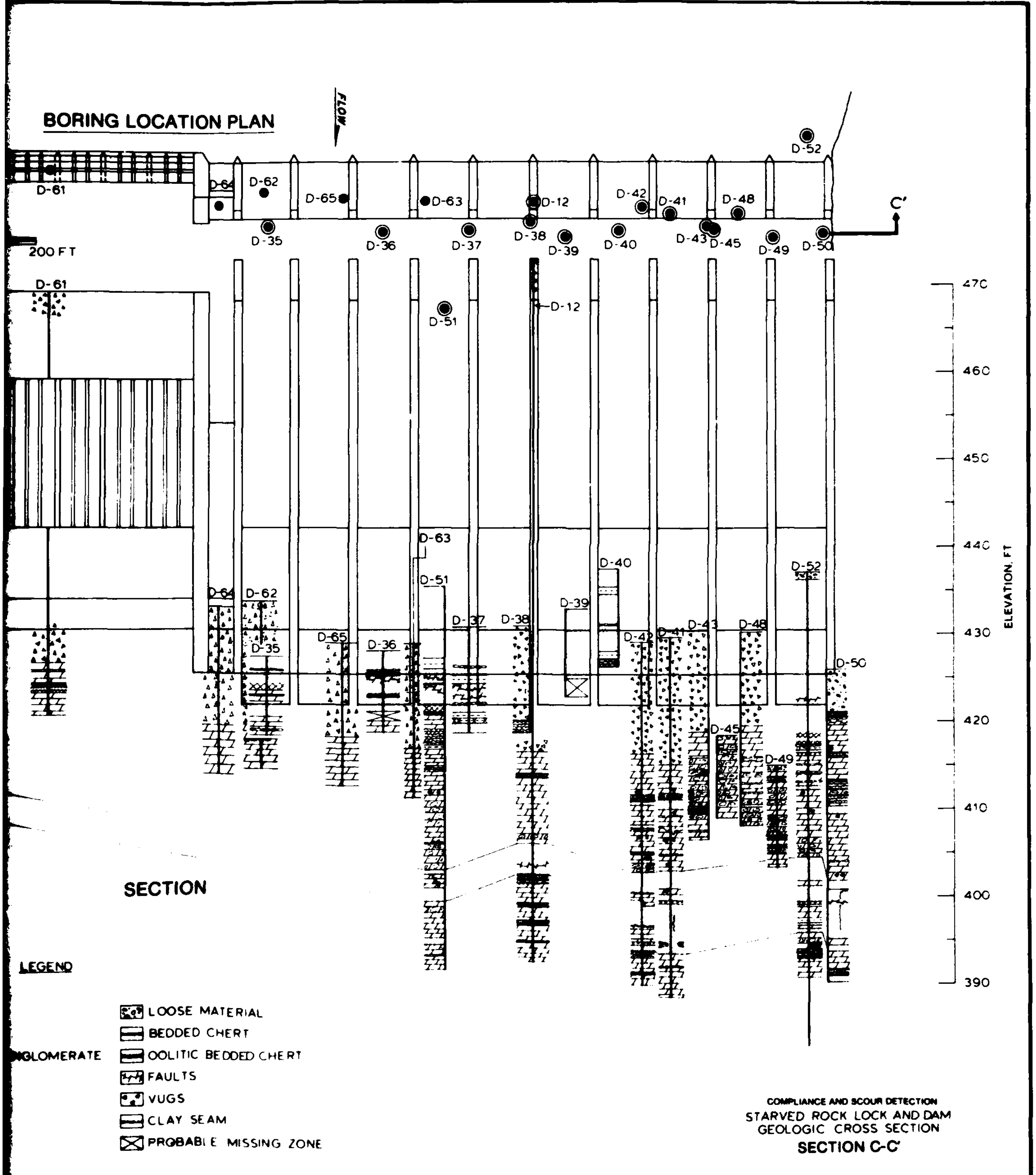
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

GEOLOGIC CROSS SECTION

SECTION B-B'

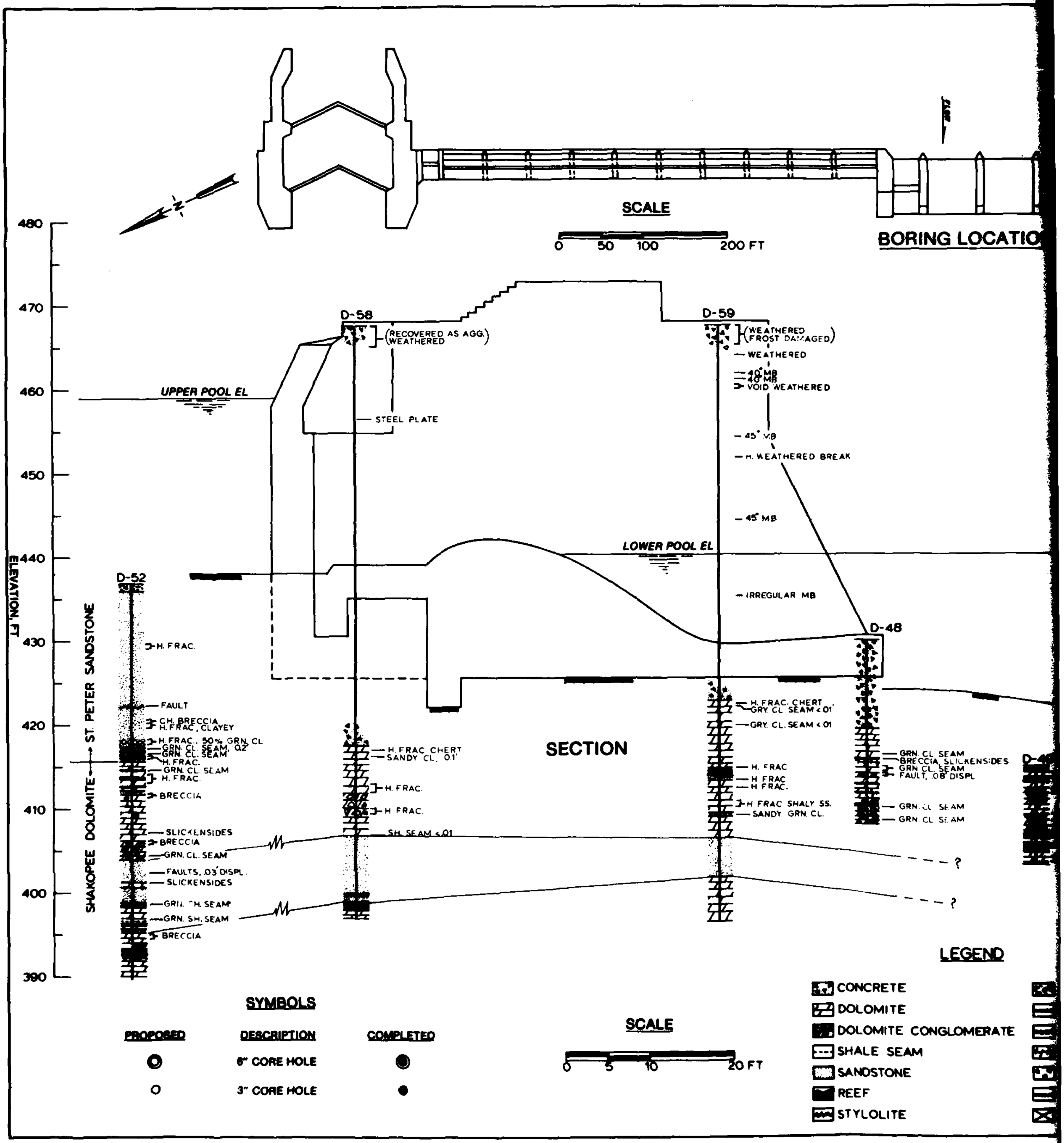


BORING LOCATION PLAN
FLOW
C
N
SAC-1
L-1
SAC-4
D-68
D-73
D-60
D-72
D-71
D-70
D-13
D-74
D-76
D-67
D-66
D-69
D-75
D-11
D-61
D-64
D-62
D-65
D-35
D-36
SCALE
0
50
100
200 FT
ELEVATION, FT
470
460
450
440
430
420
410
400
390
SECTION
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
LOOSE MATERIAL
BEDDED CHERT
OOLITIC BEDDED CHERT
FAULTS
VUGS
CLAY SEAM
PROBABLE MISSING ZONE
SYMBOLS
PROPOSED
DESCRIPTION
COMPLETED
COMBINATION DRIVE SAMPLE AND CORED
6" CORE HOLE
NX CORE HOLE

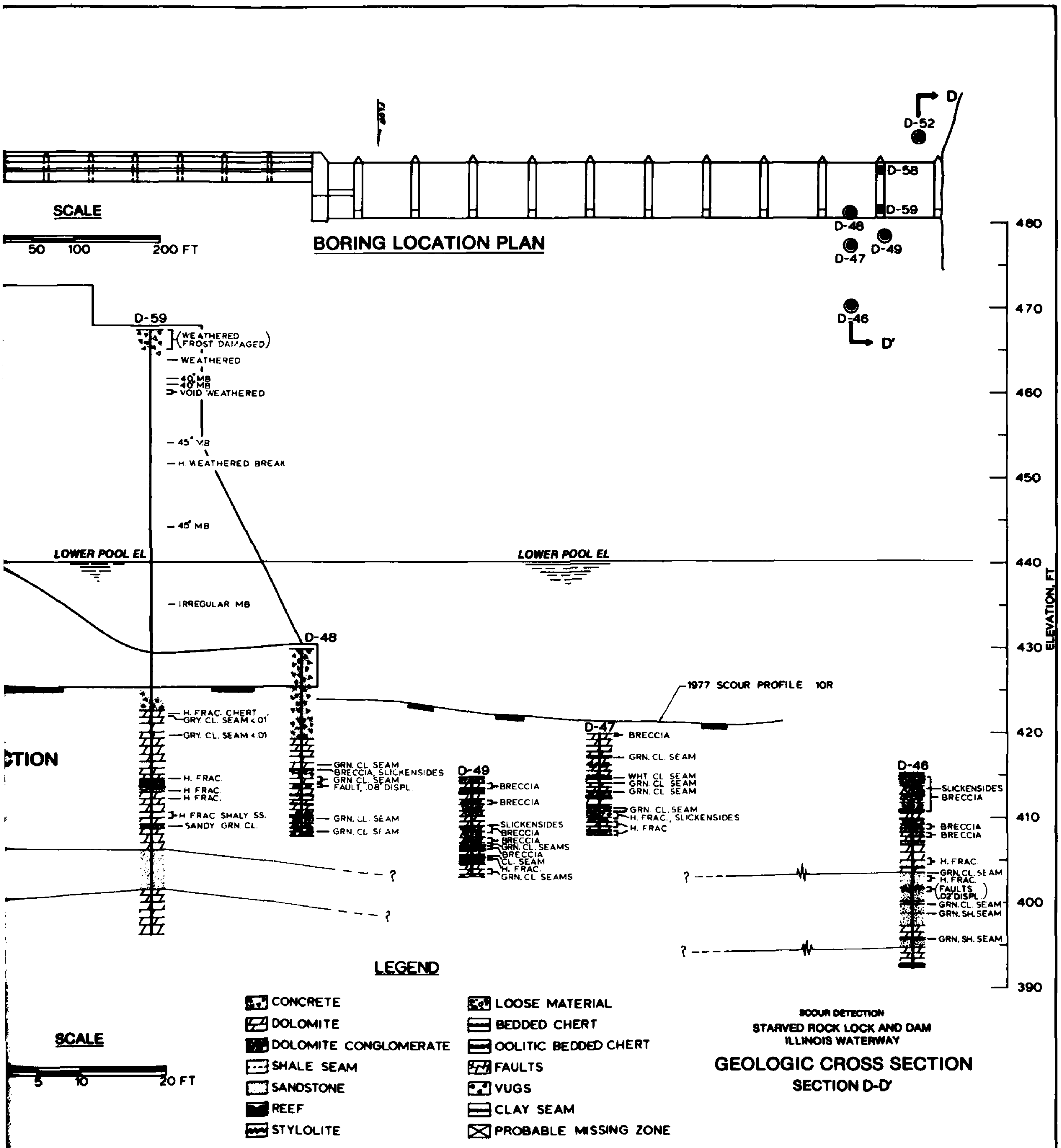


COMPLIANCE AND SCOUR DETECTION
STARVED ROCK LOCK AND DAM
GEOLOGIC CROSS SECTION
SECTION C-C'

PLATE 10



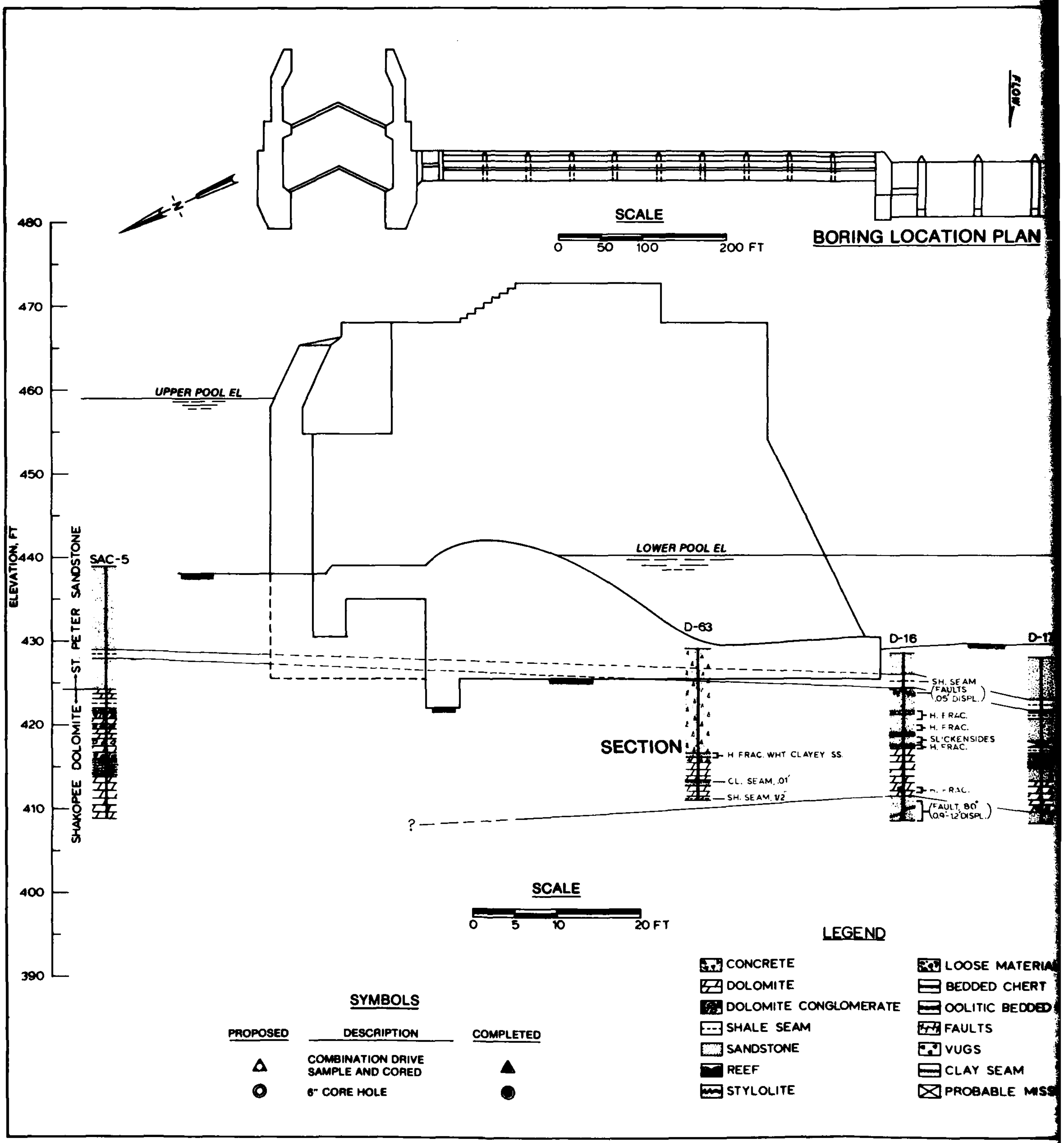
SCALE
0 50 100 200 FT
BORING LOCATIO
ELEVATION, FT
480
470
460
450
440
430
420
410
400
390
D-58
D-59
D-52
D-48
(RECOVERED AS AGG. WEATHERED)
(WEATHERED FROST DAMAGED)
WEATHERED
40° MB
40° MB
VOID WEATHERED
UPPER POOL EL
STEEL PLATE
45° MB
H. WEATHERED BREAK
45° MB
LOWER POOL EL
IRREGULAR MB
ST. PETER SANDSTONE
SHAKOPEE DOLOMITE
H. FRAC.
FAULT
CH. BRECCIA
H. FRAC., CLAYEY
H. FRAC., 50% GRN. CL
GRN. CL. SEAM, .02
GRN. CL. SEAM
H. FRAC.
GRN. CL. SEAM
H. FRAC.
BRECCIA
SLICKENSIDES
BRECCIA
GRN. CL. SEAM
FAULTS, .03' DISPL.
SLICKENSIDES
GRN. SH. SEAM
GRN. SH. SEAM
BRECCIA
H. FRAC. CHERT
SANDY CL. .01'
H. FRAC.
H. FRAC.
SH. SEAM <.01
SECTION
H. FRAC. CHERT
GRY. CL. SEAM <.01'
GRY. CL. SEAM <.01
H. FRAC.
H. FRAC.
H. FRAC.
H. FRAC. SHALY SS.
SANDY GRN. CL.
GRN. CL. SEAM
BRECCIA, SLICKENSIDES
GRN. CL. SEAM
FAULT, .08' DISPL.
GRN. CL. SEAM
GRN. CL. SEAM
?
?
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
SYMBOLS
PROPOSED
DESCRIPTION
COMPLETED
6" CORE HOLE
3" CORE HOLE
SCALE
0 5 10 20 FT



SCALE
50 100 200 FT
BORING LOCATION PLAN
D
D-52
D-58
D-59
D-48
D-49
D-47
D-46
D'
D-59
(WEATHERED FROST DAMAGED)
WEATHERED
40° MB
40° MB
VOID WEATHERED
45° MB
H. WEATHERED BREAK
45° MB
LOWER POOL EL
LOWER POOL EL
IRREGULAR MB
D-48
1977 SCOUR PROFILE 10R
H. FRAC. CHERT
GRY. CL. SEAM <.01
GRY. CL. SEAM <.01
H. FRAC.
H. FRAC.
H. FRAC.
H. FRAC. SHALY SS.
SANDY GRN. CL.
GRN. CL. SEAM
BRECCIA, SLICKENSIDES
GRN. CL. SEAM
FAULT, .08' DISPL.
GRN. CL. SEAM
GRN. CL. SEAM
D-49
BRECCIA
BRECCIA
SLICKENSIDES
BRECCIA
BRECCIA
GRN. CL. SEAMS
BRECCIA
CL. SEAM
H. FRAC.
GRN. CL. SEAMS
D-47
BRECCIA
GRN. CL. SEAM
WHT. CL. SEAM
GRN. CL. SEAM
GRN. CL. SEAM
GRN. CL. SEAM
H. FRAC., SLICKENSIDES
H. FRAC.
D-46
SLICKENSIDES
BRECCIA
BRECCIA
BRECCIA
H. FRAC.
GRN. CL. SEAM
H. FRAC.
(FAULTS .02' DISPL.)
GRN. CL. SEAM
GRN. SH. SEAM
GRN. SH. SEAM
480
470
460
450
440
430
420
410
400
390
ELEVATION, FT
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
LOOSE MATERIAL
BEDDED CHERT
OOLITIC BEDDED CHERT
FAULTS
VUGS
CLAY SEAM
PROBABLE MISSING ZONE
SCALE
5 10 20 FT
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
GEOLOGIC CROSS SECTION
SECTION D-D'

PLATE 11

2


BORING LOCATION PLAN
FLOW
N
SCALE
0 50 100 200 FT
SECTION
SCALE
0 5 10 20 FT
ELEVATION, FT
480
470
460
450
440
430
420
410
400
390
SHAKOPEE DOLOMITE — ST. PETER SANDSTONE
SAC-5
D-63
D-16
UPPER POOL EL
LOWER POOL EL
SH. SEAM
FAULTS .05' DISPL.
H. FRAC.
H. FRAC.
SLICKENSIDES
H. FRAC.
H. FRAC.
FAULT, 80° 0.9-1.2' DISPL.
H. FRAC. WHT CLAYEY SS.
CL. SEAM, .01'
SH. SEAM, 1/2'
?
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
BEDDED CHERT
FAULTS
VUGS
CLAY SEAM
SYMBOLS
PROPOSED
DESCRIPTION
COMPLETED
COMBINATION DRIVE SAMPLE AND CORED
6" CORE HOLE

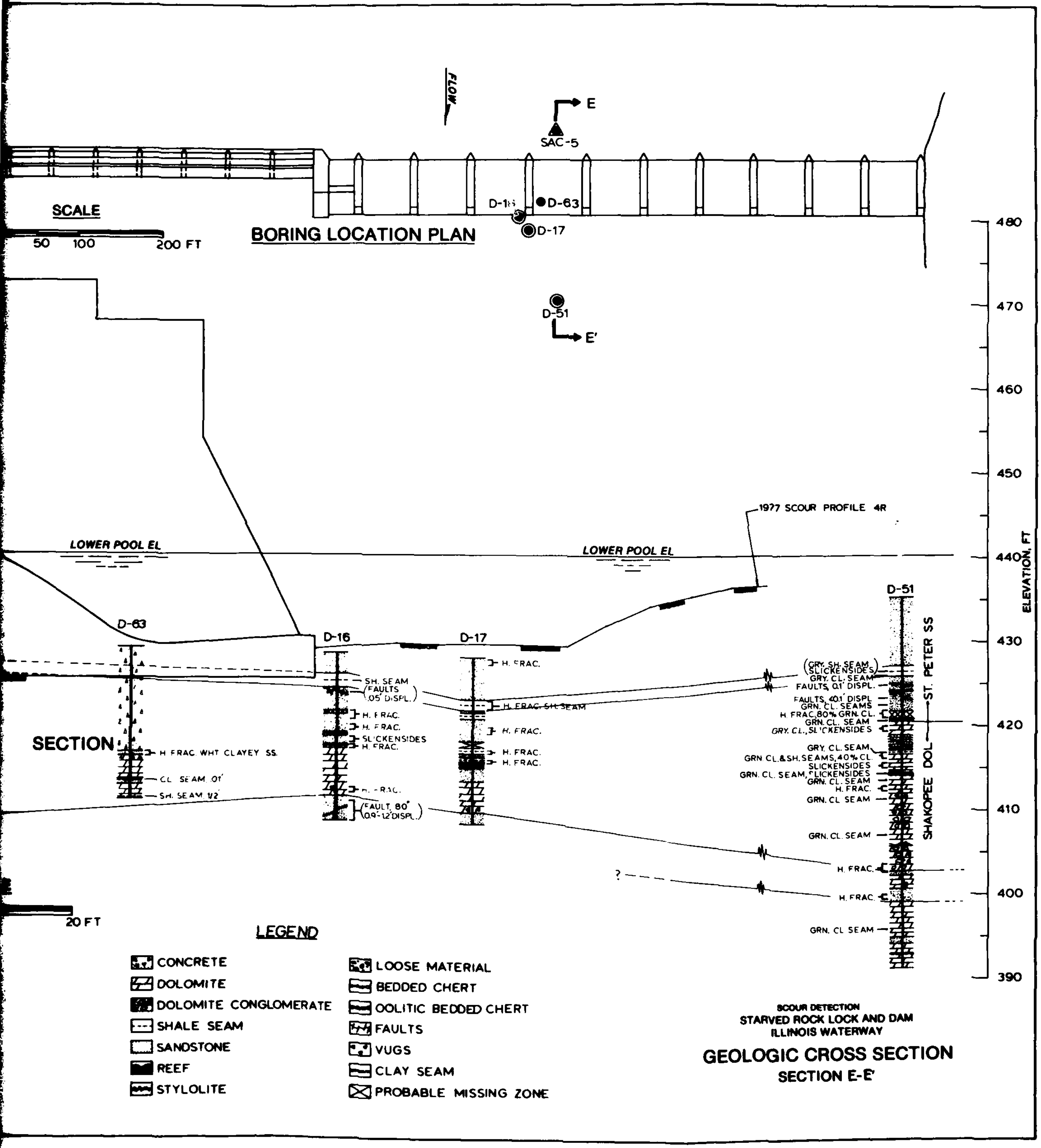
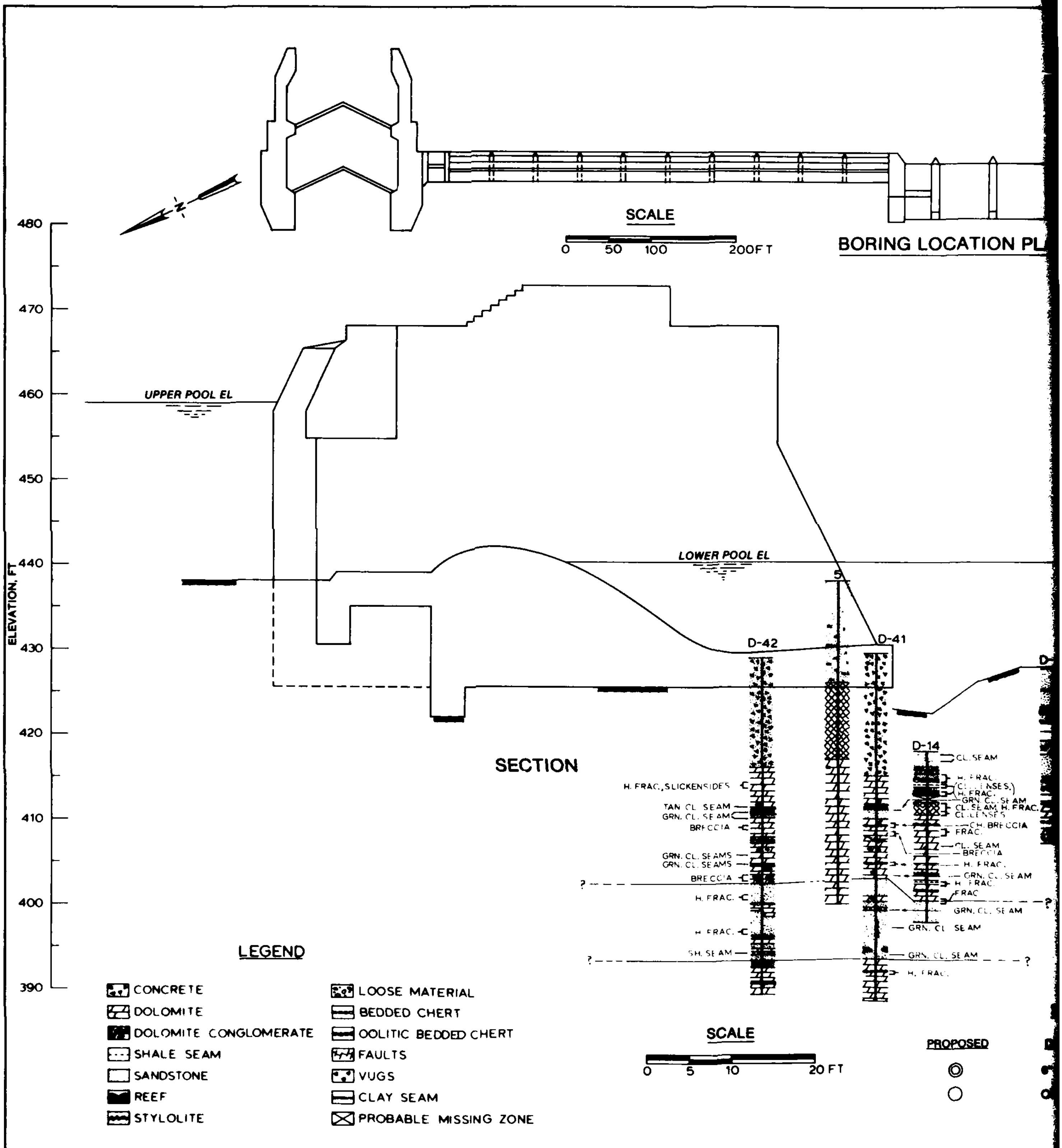
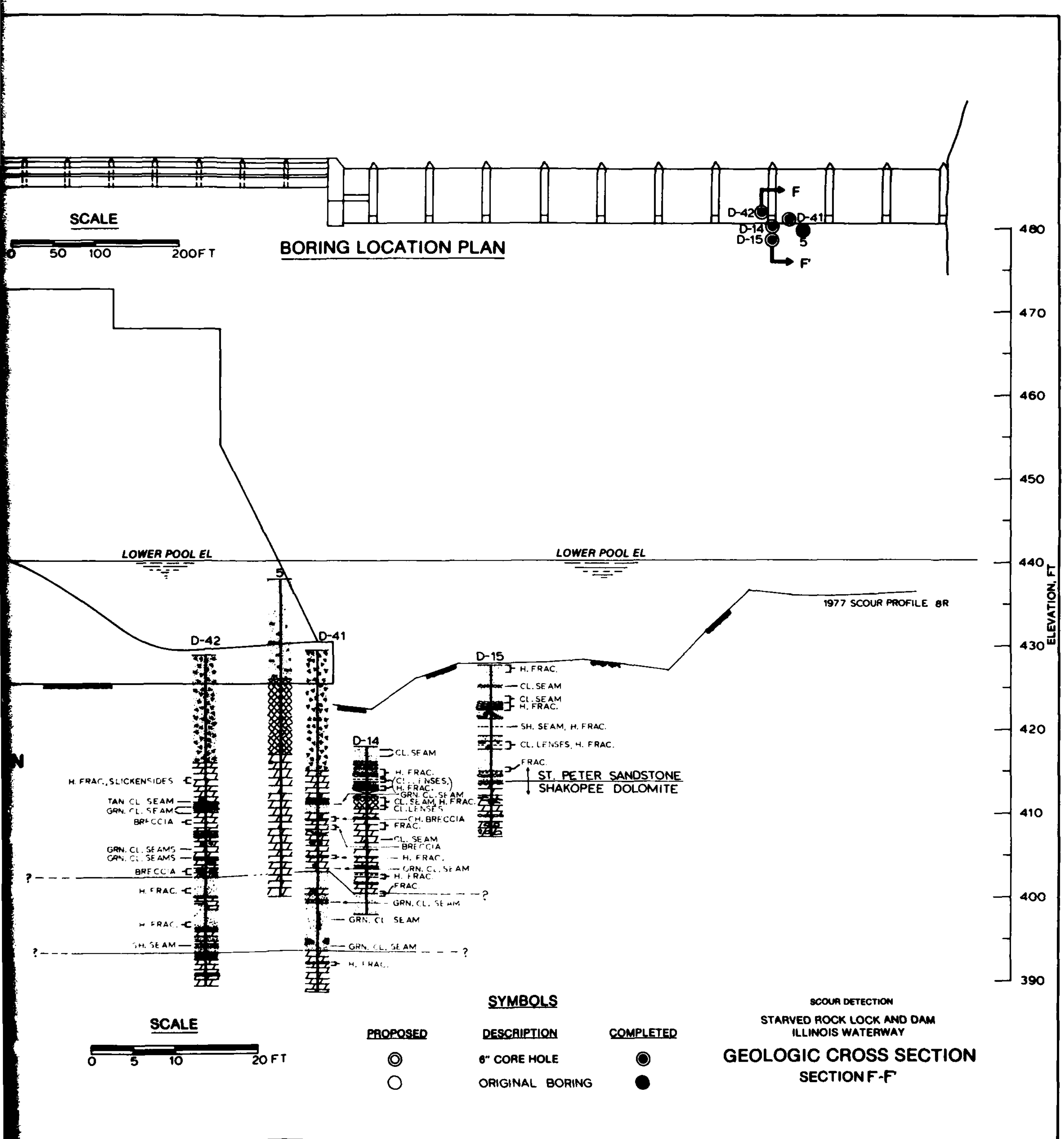

FLOW
E
SAC-5
D-16
D-63
D-17
D-51
E'
SCALE
50 100 200 FT
BORING LOCATION PLAN
LOWER POOL EL
LOWER POOL EL
1977 SCOUR PROFILE 4R
D-63
D-16
D-17
D-51
SECTION
H. FRAC. WHT. CLAYEY SS.
CL. SEAM .01'
SH. SEAM 1/2"
SH. SEAM
FAULTS .05' DISPL.
H. FRAC.
H. FRAC.
SLICKENSIDES
H. FRAC.
H. FRAC.
FAULT, 80° .09-.12' DISPL.
H. FRAC.
H. FRAC. SH. SEAM
H. FRAC.
H. FRAC.
H. FRAC.
GRY. SH. SEAM
SLICKENSIDES
GRY. CL. SEAM
FAULTS, 0.1' DISPL.
FAULTS, 40.1' DISPL.
GRN. CL. SEAMS
H. FRAC. 80% GRN. CL.
GRN. CL. SEAM
GRY. CL., SLICKENSIDES
GRY. CL. SEAM
GRN. CL. & SH. SEAMS, 40% CL.
SLICKENSIDES
GRN. CL. SEAM, SLICKENSIDES
GRN. CL. SEAM
H. FRAC.
GRN. CL. SEAM
GRN. CL. SEAM
H. FRAC.
H. FRAC.
GRN. CL. SEAM
ST. PETER SS
SHAKOPEE DOL
?
20 FT
480
470
460
450
440
430
420
410
400
390
ELEVATION, FT
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
LOOSE MATERIAL
BEDDED CHERT
OOLITIC BEDDED CHERT
FAULTS
VUGS
CLAY SEAM
PROBABLE MISSING ZONE
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
GEOLOGIC CROSS SECTION
SECTION E-E'

PLATE 12

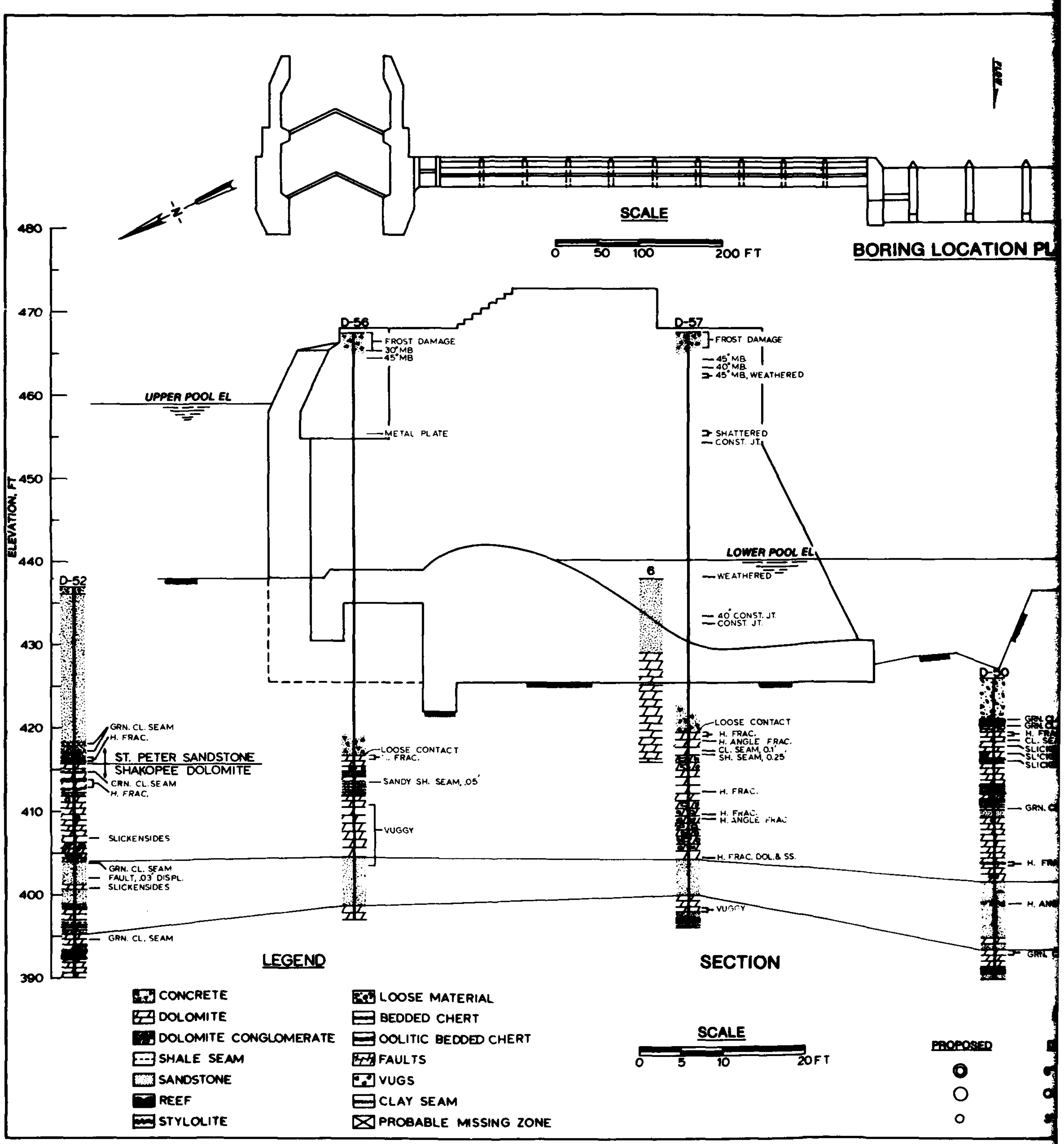


BORING LOCATION PL
SCALE
0 50 100 200 FT
N
480
470
460
450
440
430
420
410
400
390
ELEVATION, FT
UPPER POOL EL
LOWER POOL EL
SECTION
D-42
5
D-41
D-14
H. FRAC., SLICKENSIDES
TAN CL. SEAM
GRN. CL. SEAM
BRECCIA
GRN. CL. SEAMS
GRN. CL. SEAMS
BRECCIA
H. FRAC.
H. FRAC.
SH. SEAM
CL. SEAM
H. FRAC.
GRN. CL. SEAM
CH. BRECCIA
FRAC.
CL. SEAM
BRECCIA
H. FRAC.
GRN. CL. SEAM
FRAC.
GRN. CL. SEAM
GRN. CL. SEAM
GRN. CL. SEAM
H. FRAC.
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
LOOSE MATERIAL
BEDDED CHERT
OOLITIC BEDDED CHERT
FAULTS
VUGS
CLAY SEAM
PROBABLE MISSING ZONE
SCALE
0 5 10 20 FT
PROPOSED



BORING LOCATION PLAN
SCALE
0 50 100 200FT
D-42
D-41
D-14
D-15
5
F
F'
LOWER POOL EL
LOWER POOL EL
1977 SCOUR PROFILE 8R
ELEVATION, FT
480
470
460
450
440
430
420
410
400
390
D-42
D-41
D-14
D-15
5
H. FRAC., SLICKENSIDES
TAN CL. SEAM
GRN. CL. SEAM
BRECCIA
GRN. CL. SEAMS
GRN. CL. SEAMS
BRECCIA
H. FRAC.
H. FRAC.
SH. SEAM
GRN. CL. SEAM
GRN. CL. SEAM
H. FRAC.
CL. SEAM
H. FRAC.
CL. LENSES
H. FRAC.
GRN. CL. SEAM
CL. SEAM, H. FRAC.
CL. LENSES
CH. BRECCIA
FRAC.
CL. SEAM
BRECCIA
H. FRAC.
GRN. CL. SEAM
H. FRAC.
FRAC.
GRN. CL. SEAM
H. FRAC.
CL. SEAM
CL. SEAM
H. FRAC.
SH. SEAM, H. FRAC.
CL. LENSES, H. FRAC.
FRAC.
ST. PETER SANDSTONE
SHAKOPEE DOLOMITE
SCALE
0 5 10 20 FT
SYMBOLS
PROPOSED
DESCRIPTION
COMPLETED
6" CORE HOLE
ORIGINAL BORING
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
GEOLOGIC CROSS SECTION
SECTION F-F'

PLATE 13


SCALE
0 50 100 200 FT
BORING LOCATION PL
ELEVATION, FT
480
470
460
450
440
430
420
410
400
390
UPPER POOL EL
LOWER POOL EL
D-56
FROST DAMAGE
30°MB
45°MB
METAL PLATE
D-57
FROST DAMAGE
45°MB
40°MB
45°MB, WEATHERED
SHATTERED
CONST. JT.
WEATHERED
40° CONST. JT.
CONST. JT.
6
D-52
GRN. CL. SEAM
H. FRAC.
ST. PETER SANDSTONE
SHAKOPEE DOLOMITE
GRN. CL. SEAM
H. FRAC.
SLICKENSIDES
GRN. CL. SEAM
FAULT, .03' DISPL.
SLICKENSIDES
GRN. CL. SEAM
LOOSE CONTACT
SANDY SH. SEAM, .05'
VUGGY
LOOSE CONTACT
H. FRAC.
H. ANGLE FRAC.
CL. SEAM, 0.1'
SH. SEAM, 0.25'
H. FRAC.
H. FRAC.
H. FRAC. DOL.& SS.
VUGGY
LEGEND
SECTION
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
LOOSE MATERIAL
BEDDED CHERT
OOLITIC BEDDED CHERT
FAULTS
VUGS
CLAY SEAM
PROBABLE MISSING ZONE
SCALE
0 5 10 20 FT
PROPOSED

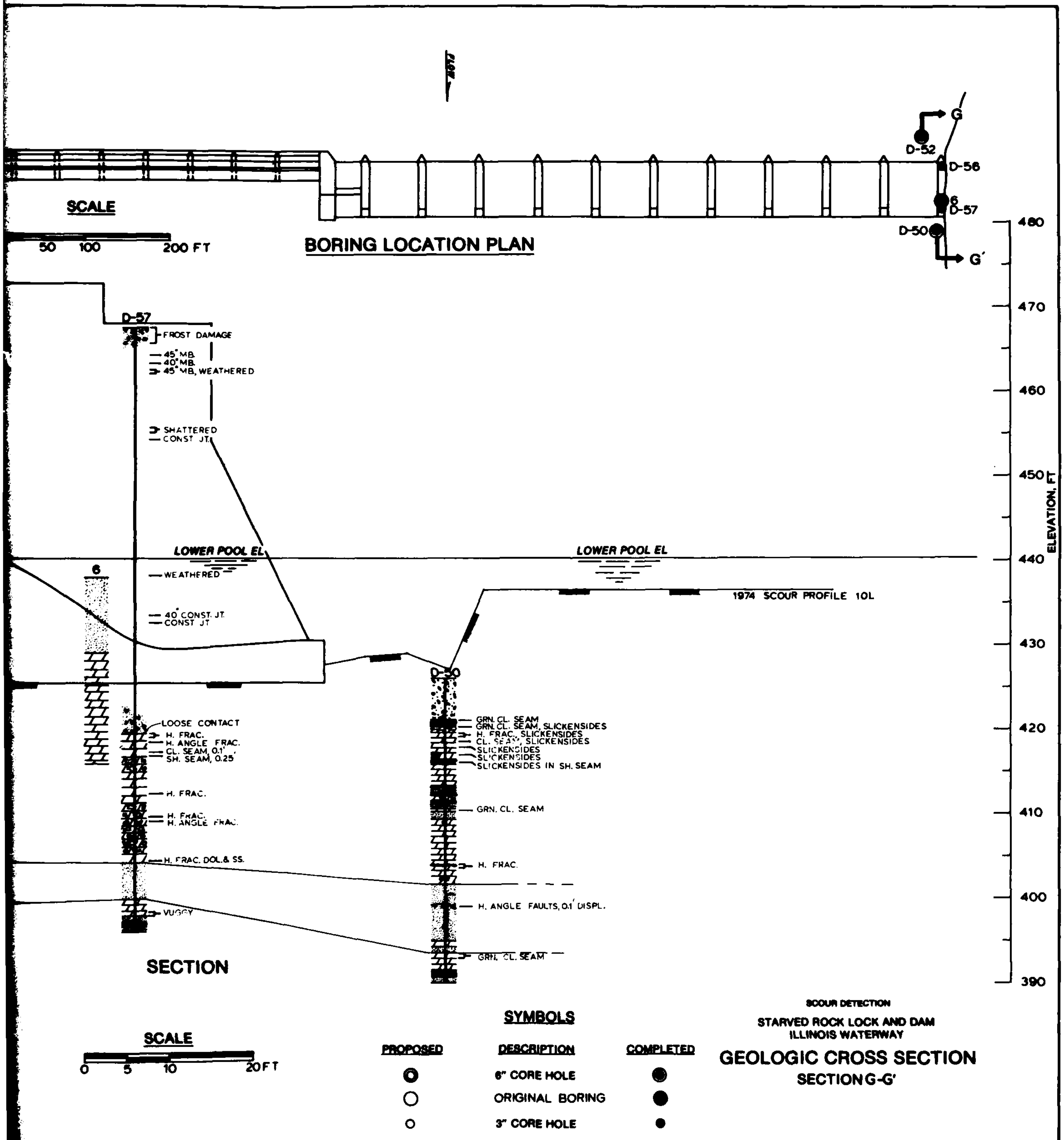
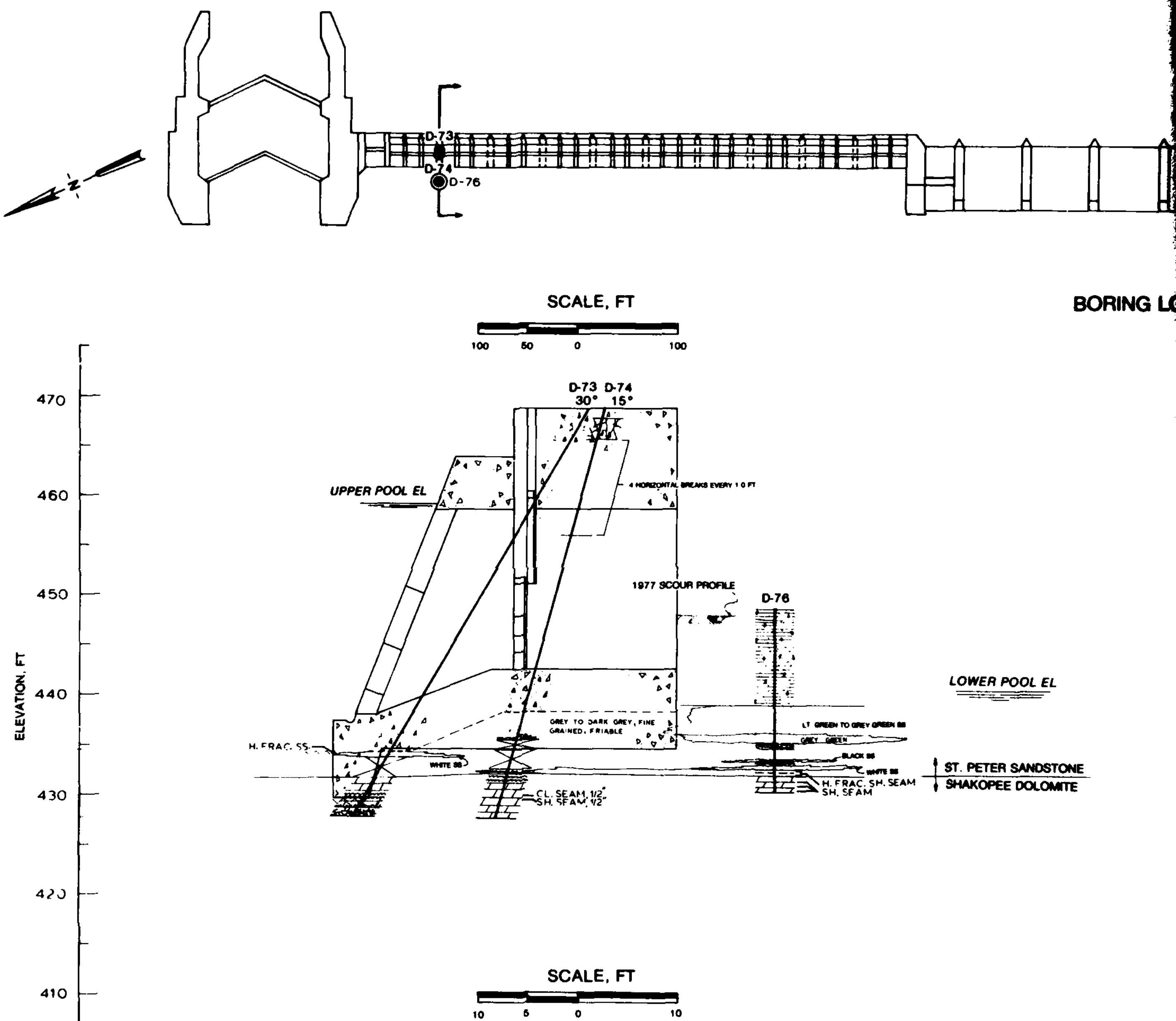

BORING LOCATION PLAN
SCALE
50 100 200 FT
G
G′
D-52
D-56
6
D-57
D-50
D-57
FROST DAMAGE
45° MB.
40° MB.
45° MB, WEATHERED
SHATTERED
CONST. JT.
LOWER POOL EL
LOWER POOL EL
WEATHERED
40° CONST. JT.
CONST. JT.
6
1974 SCOUR PROFILE 10L
D-50
LOOSE CONTACT
H. FRAC.
H. ANGLE FRAC.
CL. SEAM, 0.1′
SH. SEAM, 0.25′
H. FRAC.
H. FRAC.
H. ANGLE FRAC.
H. FRAC. DOL.& SS.
VUGGY
GRN. CL. SEAM
GRN. CL. SEAM, SLICKENSIDES
H. FRAC., SLICKENSIDES
CL. SEAM, SLICKENSIDES
SLICKENSIDES
SLICKENSIDES
SLICKENSIDES IN SH. SEAM
GRN. CL. SEAM
H. FRAC.
H. ANGLE FAULTS, 0.1′ DISPL.
GRN. CL. SEAM
SECTION
ELEVATION, FT
480
470
460
450
440
430
420
410
400
390
SCALE
0 5 10 20 FT
SYMBOLS
PROPOSED
DESCRIPTION
COMPLETED
6″ CORE HOLE
ORIGINAL BORING
3″ CORE HOLE
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
GEOLOGIC CROSS SECTION
SECTION G-G′

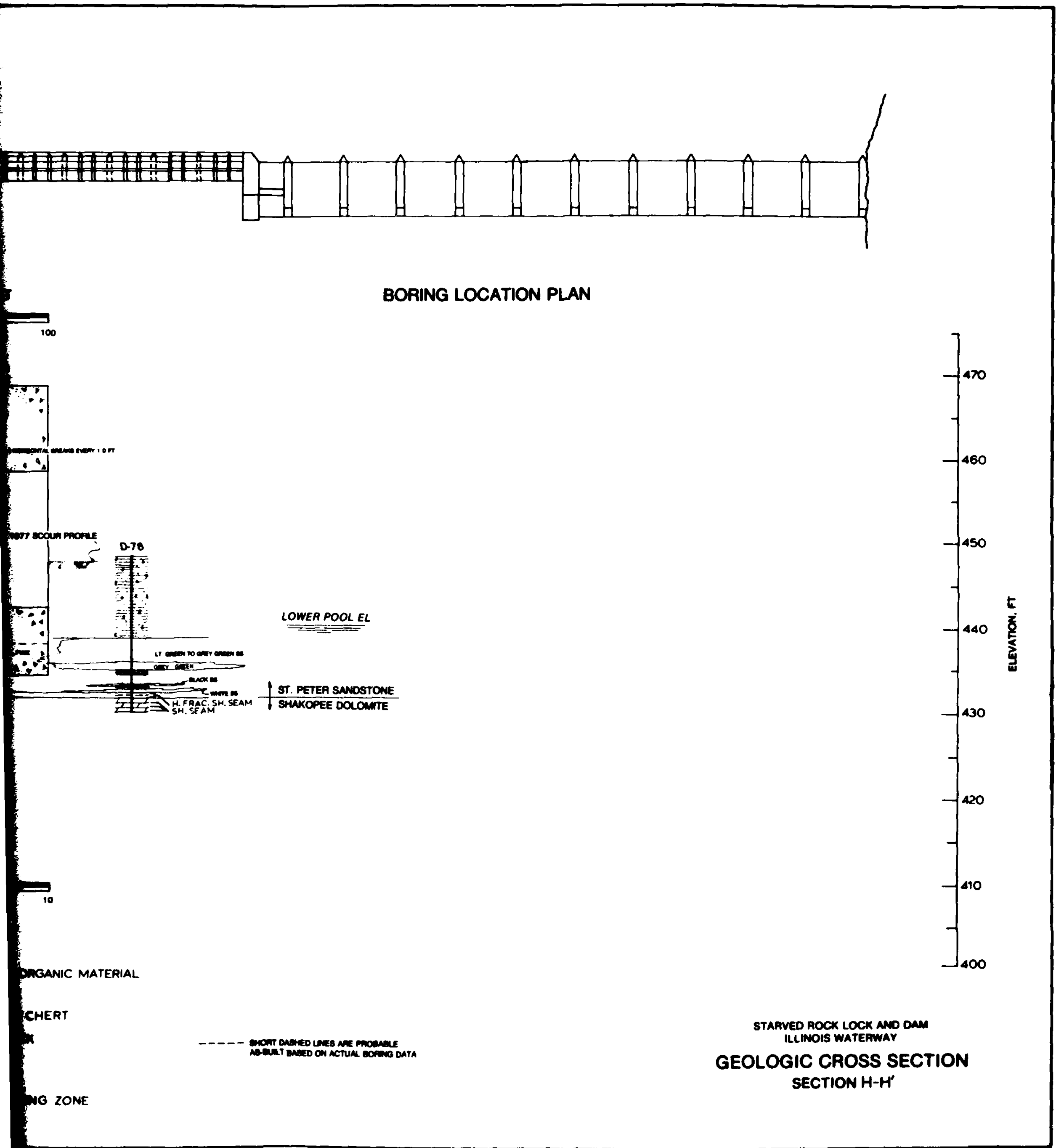
PLATE 14a



LEGEND

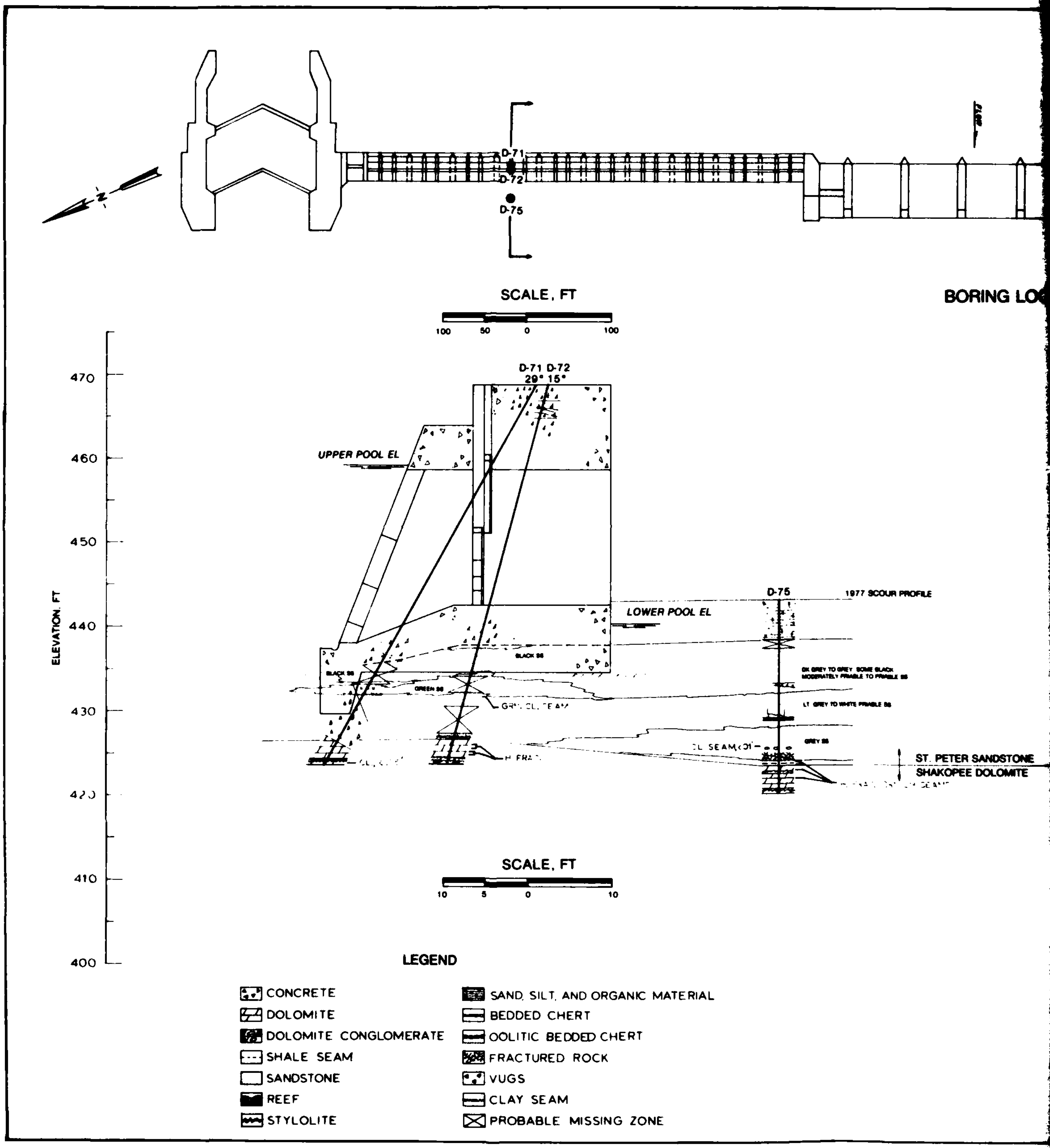
- CONCRETE
- DOLOMITE
- DOLOMITE CONGLOMERATE
- SHALE SEAM
- SANDSTONE
- REEF
- STYLOLITE
- SAND, SILT, AND ORGANIC MATERIAL
- BEDDED CHERT
- OOLITIC BEDDED CHERT
- FRACTURED ROCK
- VUGS
- CLAY SEAM
- PROBABLE MISSING ZONE

SHORT DASHED LINES ARE PROBABLE AS-BUILT BASED ON ACTUAL BORING DATA

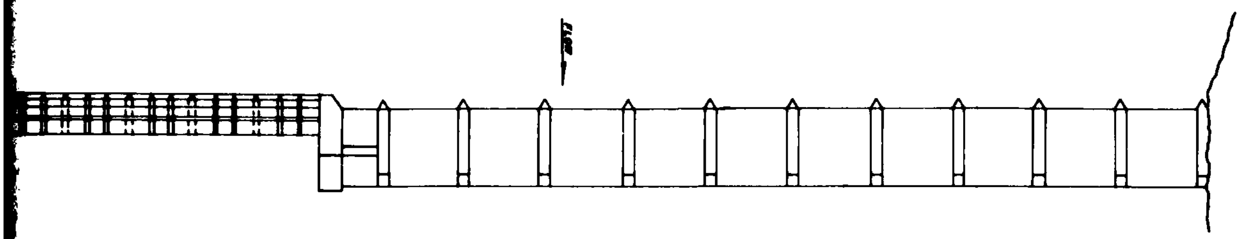


BORING LOCATION PLAN
100
1977 SCOUR PROFILE
D-76
LOWER POOL EL
LT GREEN TO GREY GREEN SS
GREY GREEN
BLACK SS
WHITE SS
H. FRAC. SH. SEAM
SH. SEAM
ST. PETER SANDSTONE
SHAKOPEE DOLOMITE
470
460
450
440
430
420
410
400
ELEVATION, FT
10
ORGANIC MATERIAL
CHERT
NG ZONE
SHORT DASHED LINES ARE PROBABLE
AS-BUILT BASED ON ACTUAL BORING DATA
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY
GEOLOGIC CROSS SECTION
SECTION H-H'

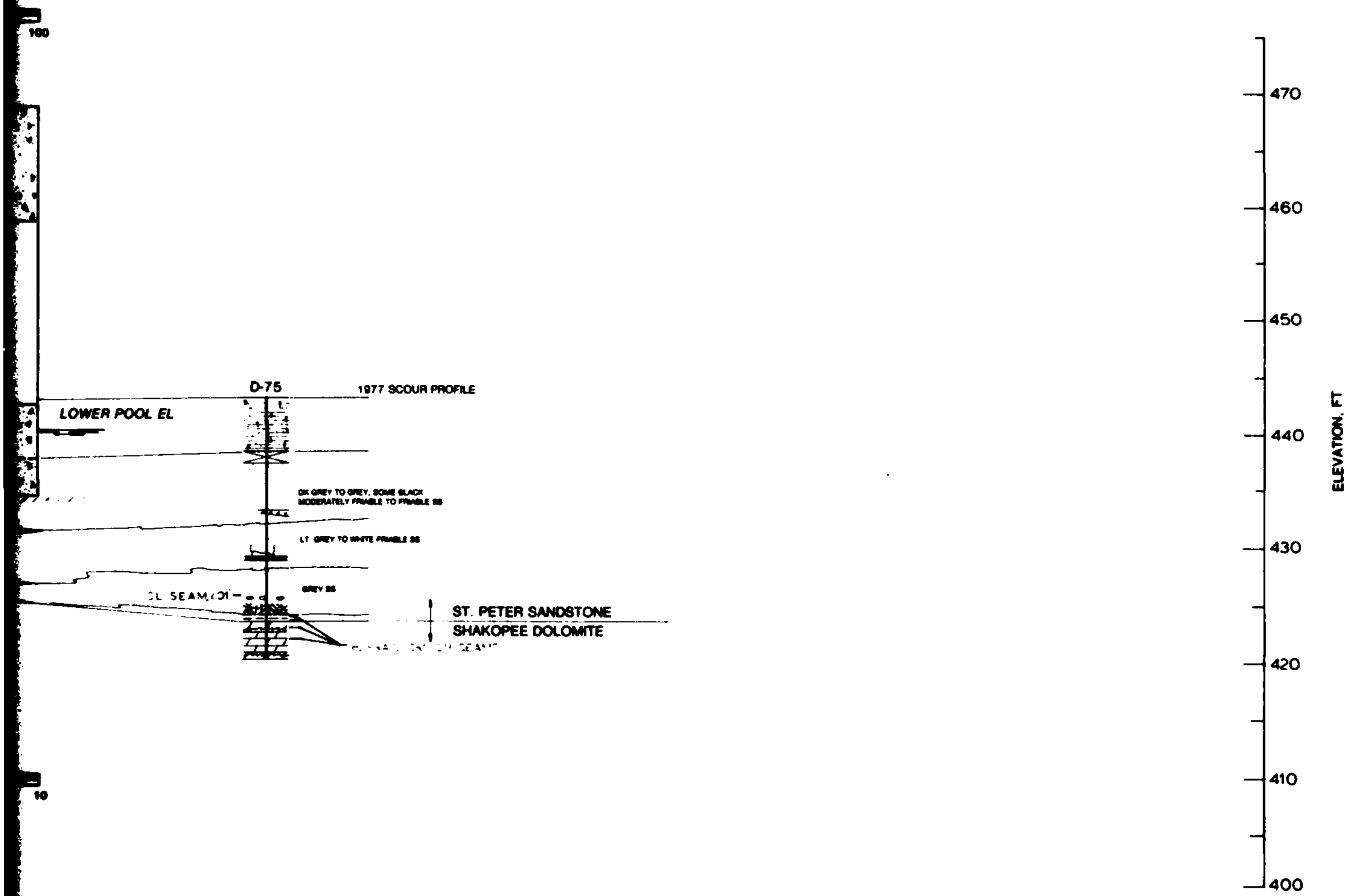
PLATE 14b



D-71
D-72
D-75
SCALE, FT
100 50 0 100
BORING LO
D-71 D-72
29° 15°
UPPER POOL EL
LOWER POOL EL
1977 SCOUR PROFILE
ELEVATION, FT
470
460
450
440
430
410
400
BLACK SS
GREEN SS
LT GREY TO WHITE FRIABLE SS
GREY SS
ST. PETER SANDSTONE
SHAKOPEE DOLOMITE
SCALE, FT
10 5 0 10
LEGEND
CONCRETE
DOLOMITE
DOLOMITE CONGLOMERATE
SHALE SEAM
SANDSTONE
REEF
STYLOLITE
SAND, SILT, AND ORGANIC MATERIAL
BEDDED CHERT
OOLITIC BEDDED CHERT
FRACTURED ROCK
VUGS
CLAY SEAM
PROBABLE MISSING ZONE



BORING LOCATION PLAN



RGANIC MATERIAL

CHERT

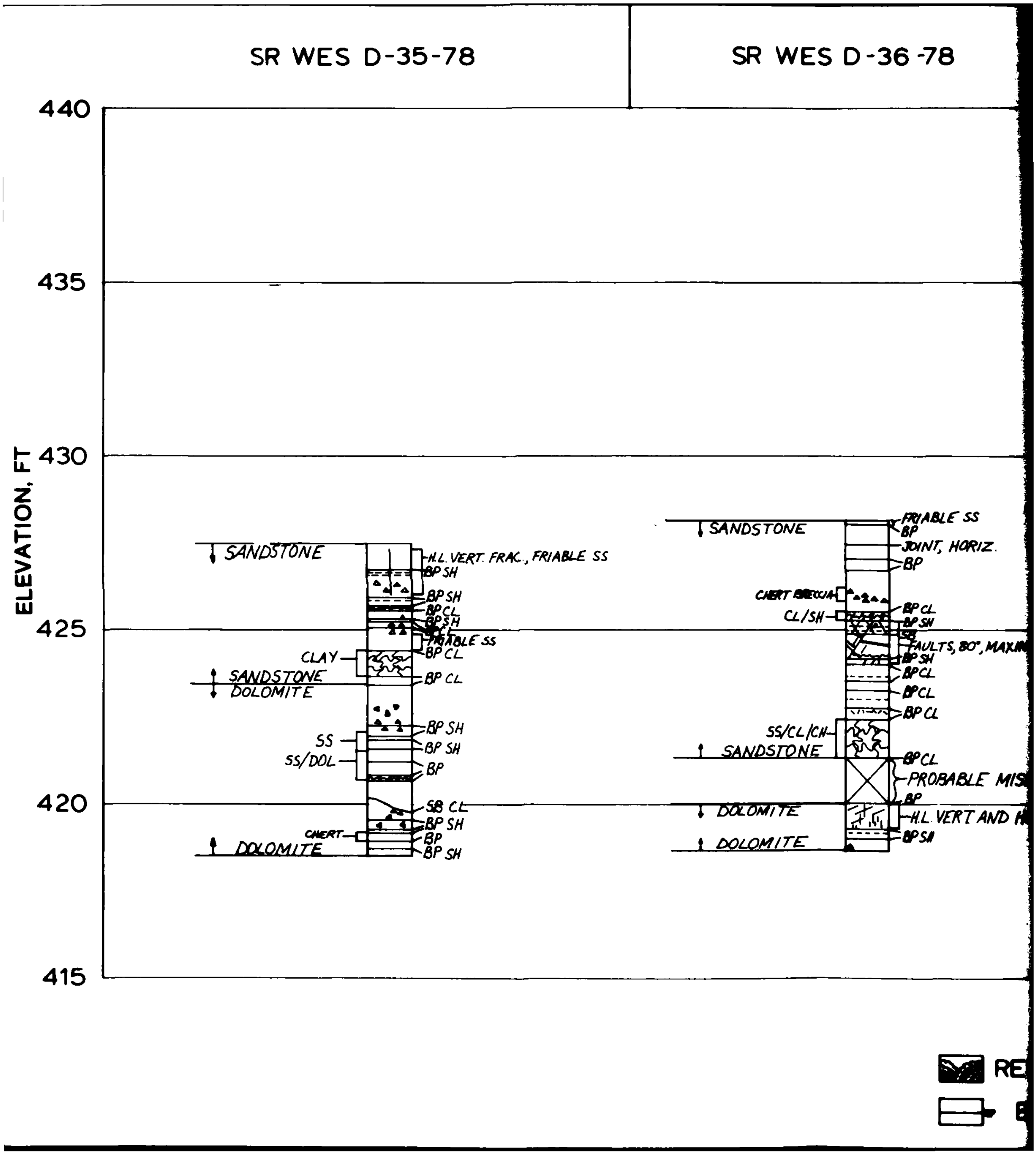
K

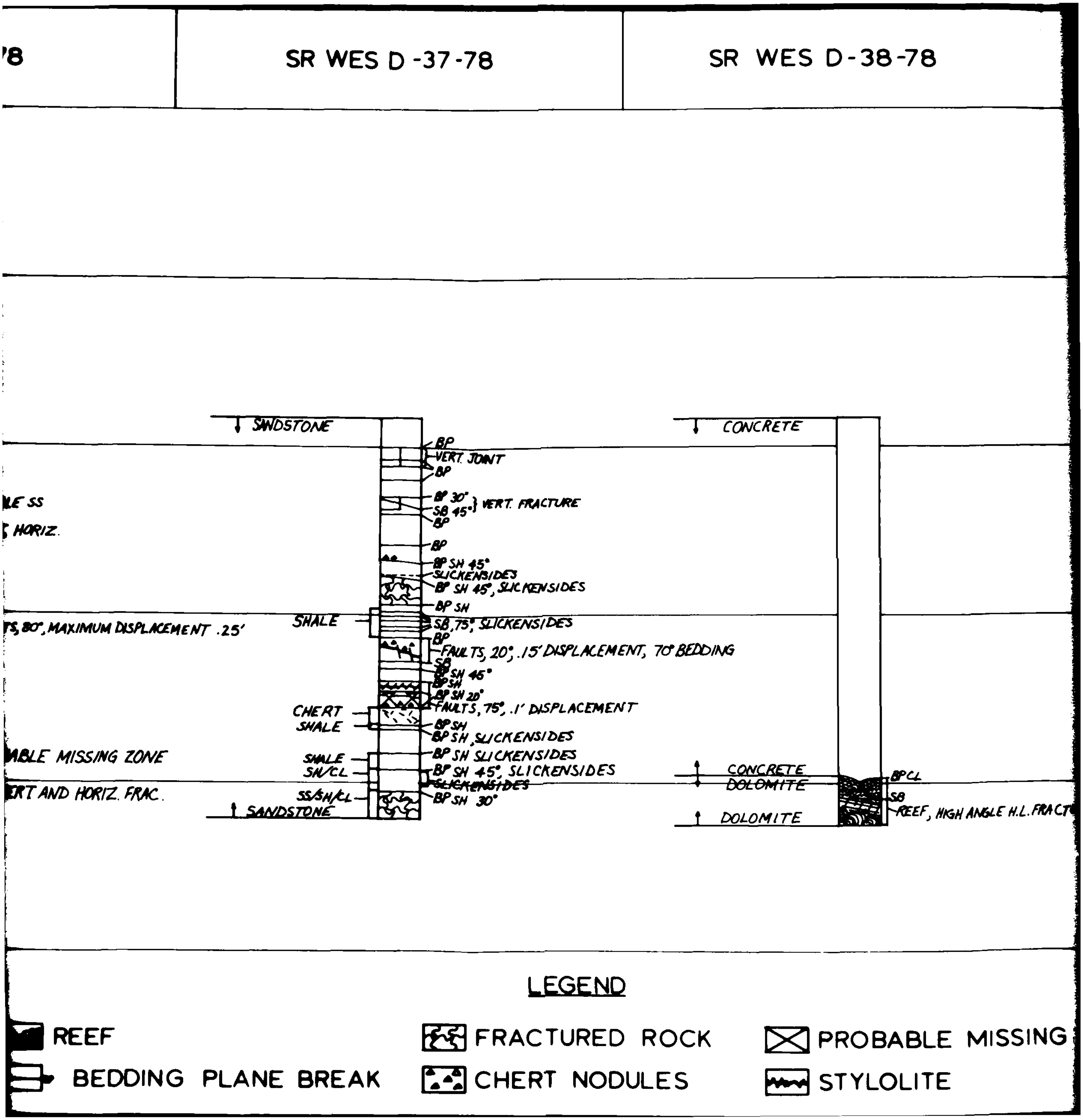
NG ZONE

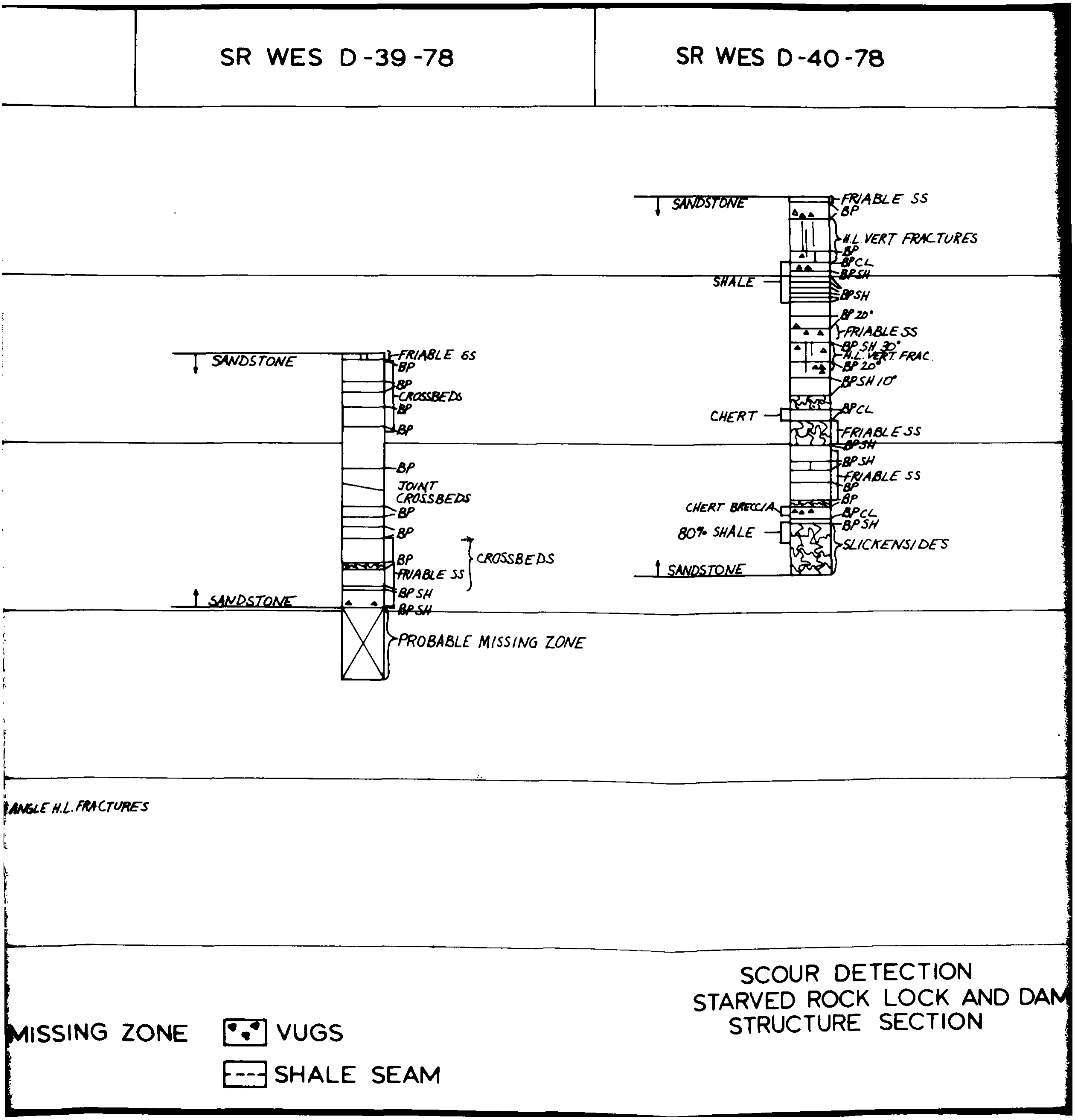
STARVED ROCK LOCK AND DAM
ILLINOIS WATERWAY

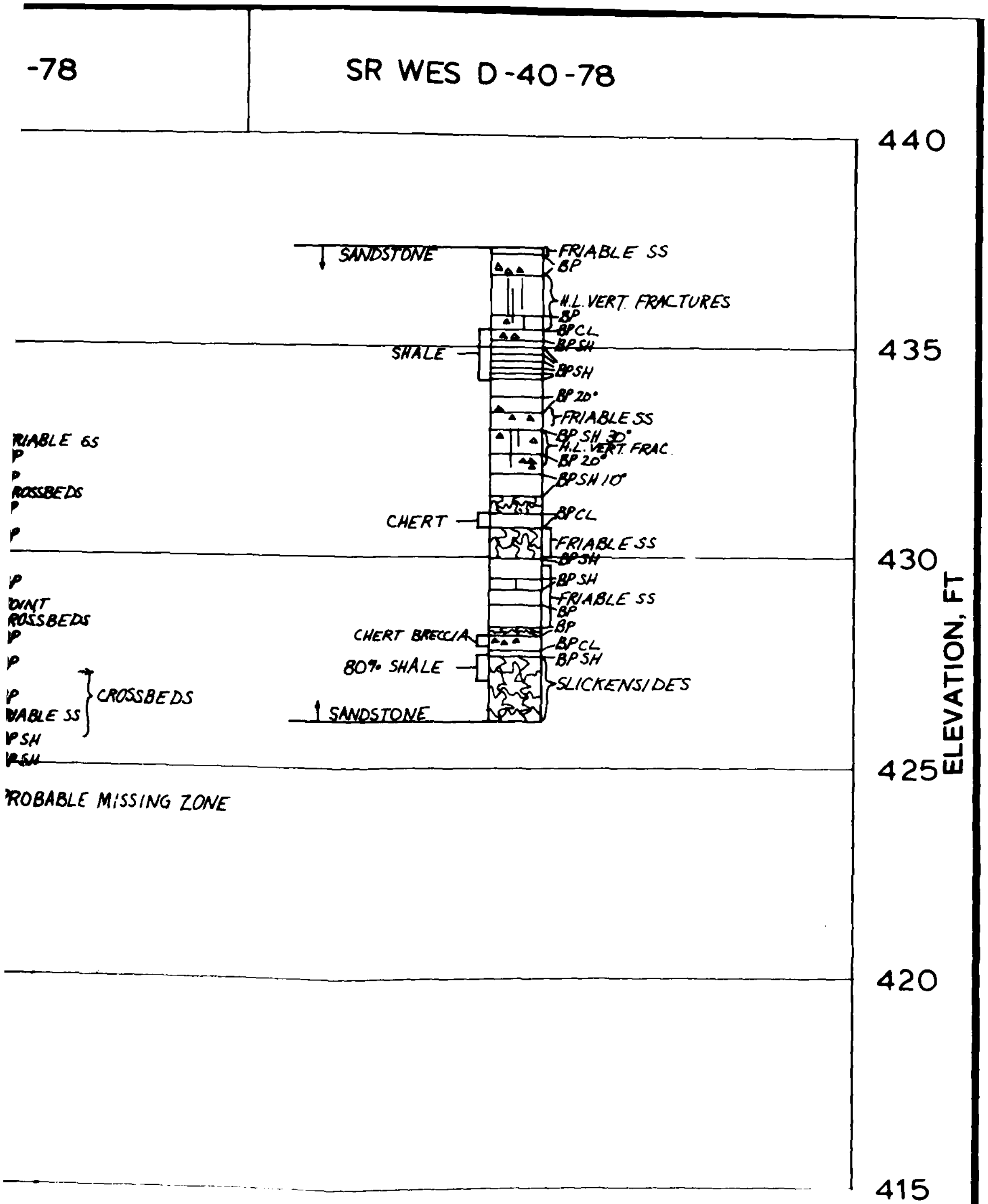
GEOLOGIC CROSS SECTION

SECTION I-I'


SR WES D-35-78
SR WES D-36-78
ELEVATION, FT
440
435
430
425
420
415
SANDSTONE
H.L. VERT. FRAC., FRIABLE SS
BP SH
BP SH
BP CL
BP SH
FRIABLE SS
CLAY
BP CL
SANDSTONE
DOLOMITE
BP CL
BP SH
SS
BP SH
SS/DOL
BP
SB CL
BP SH
CHERT
BP
DOLOMITE
BP SH
SANDSTONE
FRIABLE SS
BP
JOINT, HORIZ.
BP
CHERT BRECCIA
BP CL
CL/SH
BP SH
SS
FAULTS, 80°, MAXIN
BP SH
BP CL
BP CL
BP CL
SS/CL/CH
SANDSTONE
BP CL
PROBABLE MIS
BP
DOLOMITE
H.L. VERT AND H
BP SH
DOLOMITE
RE

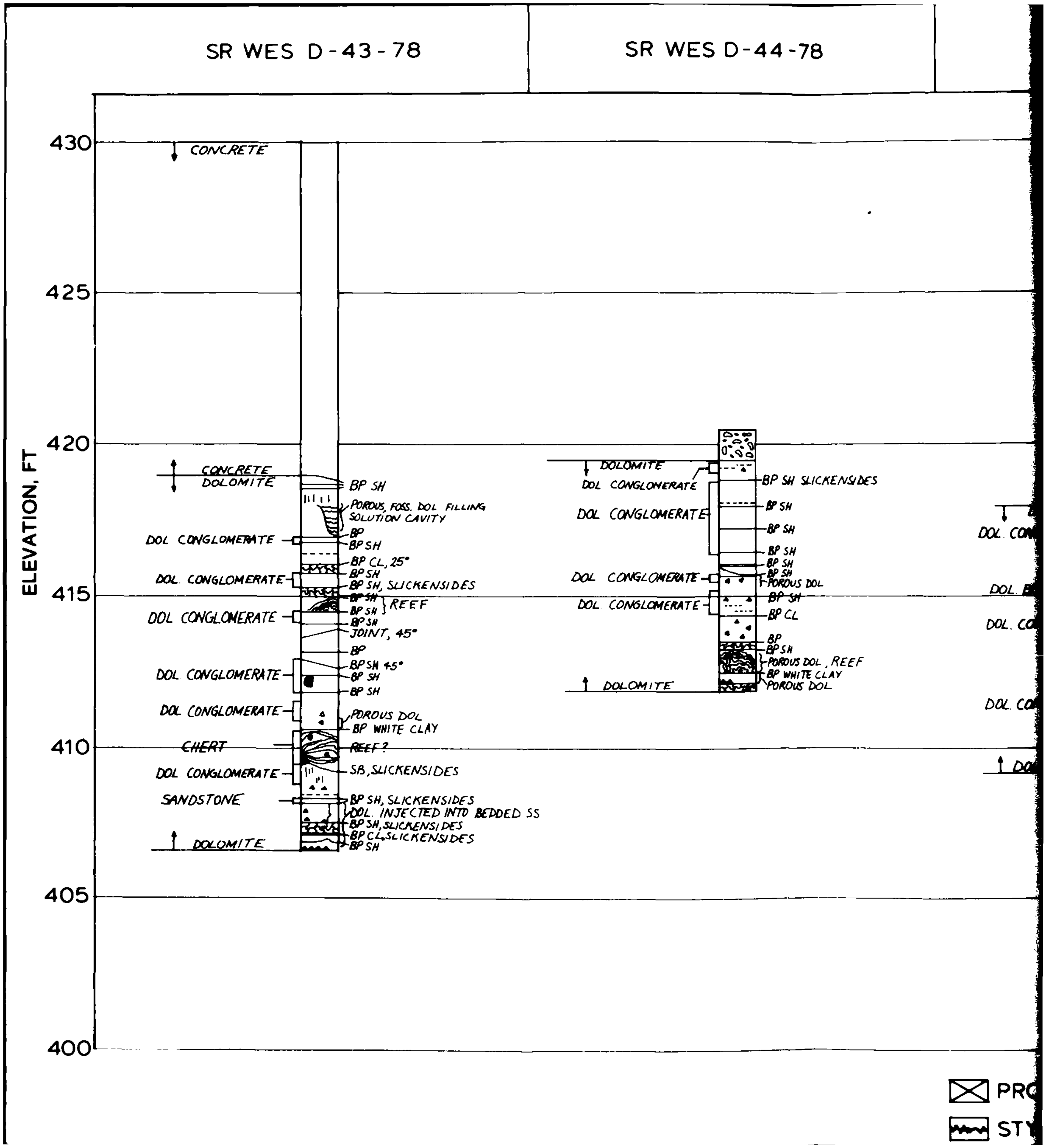

'78
SR WES D-37-78
SR WES D-38-78
SANDSTONE
BP
VERT. JOINT
BP
BP 30°
SB 45°
VERT. FRACTURE
BP
LE SS
HORIZ.
BP
BP SH 45°
SLICKENSIDES
BP SH 45°, SLICKENSIDES
BP SH
SHALE
SB, 75°, SLICKENSIDES
TS, 80°, MAXIMUM DISPLACEMENT .25'
BP
FAULTS, 20°, .15' DISPLACEMENT, 70° BEDDING
SB
BP SH 45°
BP SH
BP SH 20°
FAULTS, 75°, .1' DISPLACEMENT
CHERT
SHALE
BP SH
BP SH, SLICKENSIDES
ABLE MISSING ZONE
SHALE
BP SH SLICKENSIDES
SH/CL
BP SH 45°, SLICKENSIDES
SLICKENSIDES
ERT AND HORIZ. FRAC.
SS/SH/CL
BP SH 30°
SANDSTONE
CONCRETE
CONCRETE
DOLOMITE
BP CL
SB
REEF, HIGH ANGLE H.L. FRACT
DOLOMITE
LEGEND
REEF
BEDDING PLANE BREAK
FRACTURED ROCK
CHERT NODULES
PROBABLE MISSING
STYLOLITE

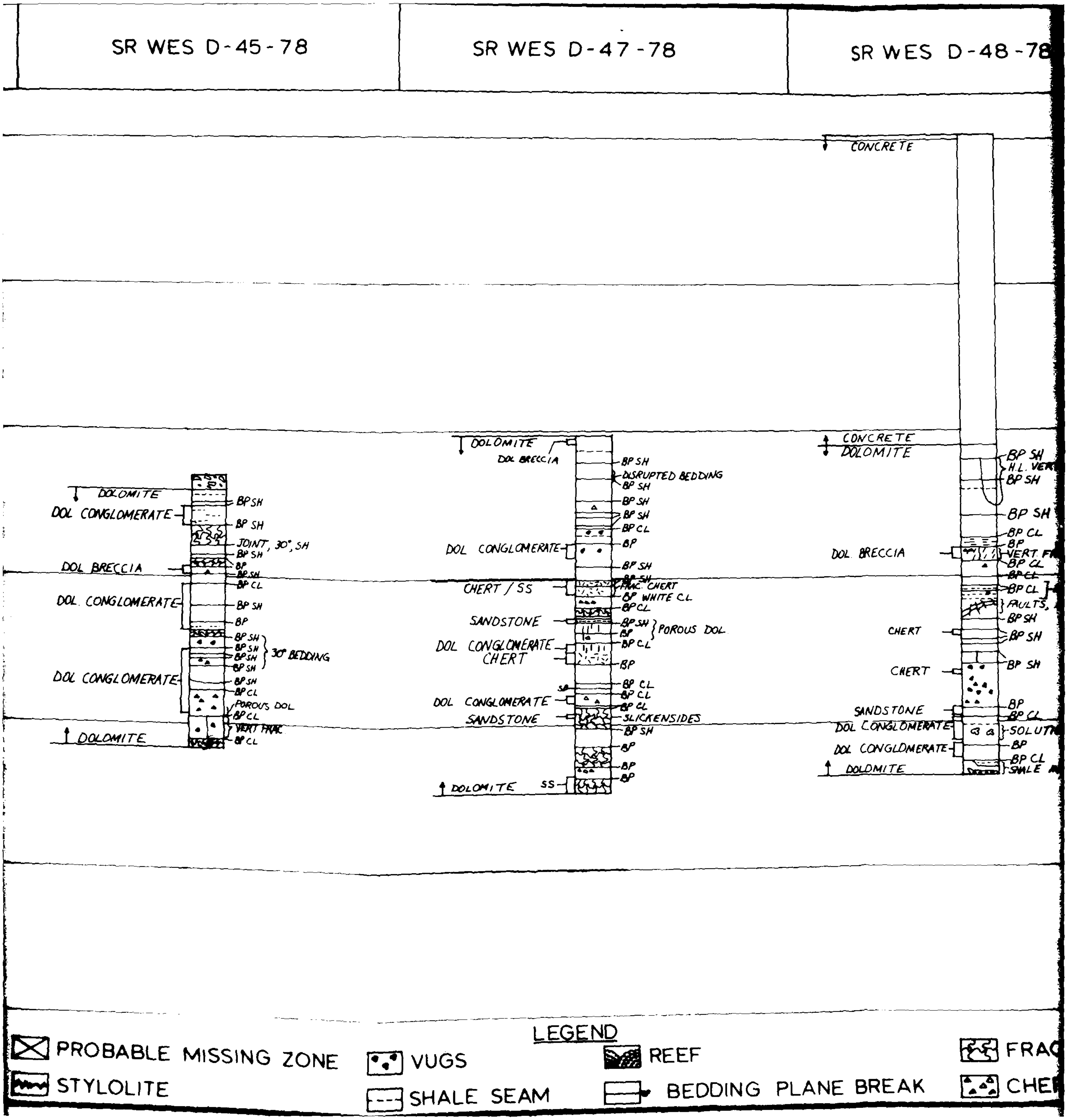

SR WES D-39-78
SR WES D-40-78
SANDSTONE
FRIABLE SS
BP
CROSSBEDS
BP
BP
BP
JOINT
CROSSBEDS
BP
BP
BP
FRIABLE SS
CROSSBEDS
BP SH
SANDSTONE
BP SH
PROBABLE MISSING ZONE
SANDSTONE
FRIABLE SS
BP
H.L. VERT FRACTURES
BP
BP CL
SHALE
BP SH
BP SH
BP 20°
FRIABLE SS
BP SH 30°
H.L. VERT. FRAC.
BP 20°
BP SH 10°
CHERT
BP CL
FRIABLE SS
BP SH
BP SH
FRIABLE SS
BP
BP
CHERT BRECCIA
BP CL
BP SH
80% SHALE
SLICKENSIDES
SANDSTONE
ANGLE H.L. FRACTURES
MISSING ZONE
VUGS
SHALE SEAM
SCOUR DETECTION
STARVED ROCK LOCK AND DAM
STRUCTURE SECTION

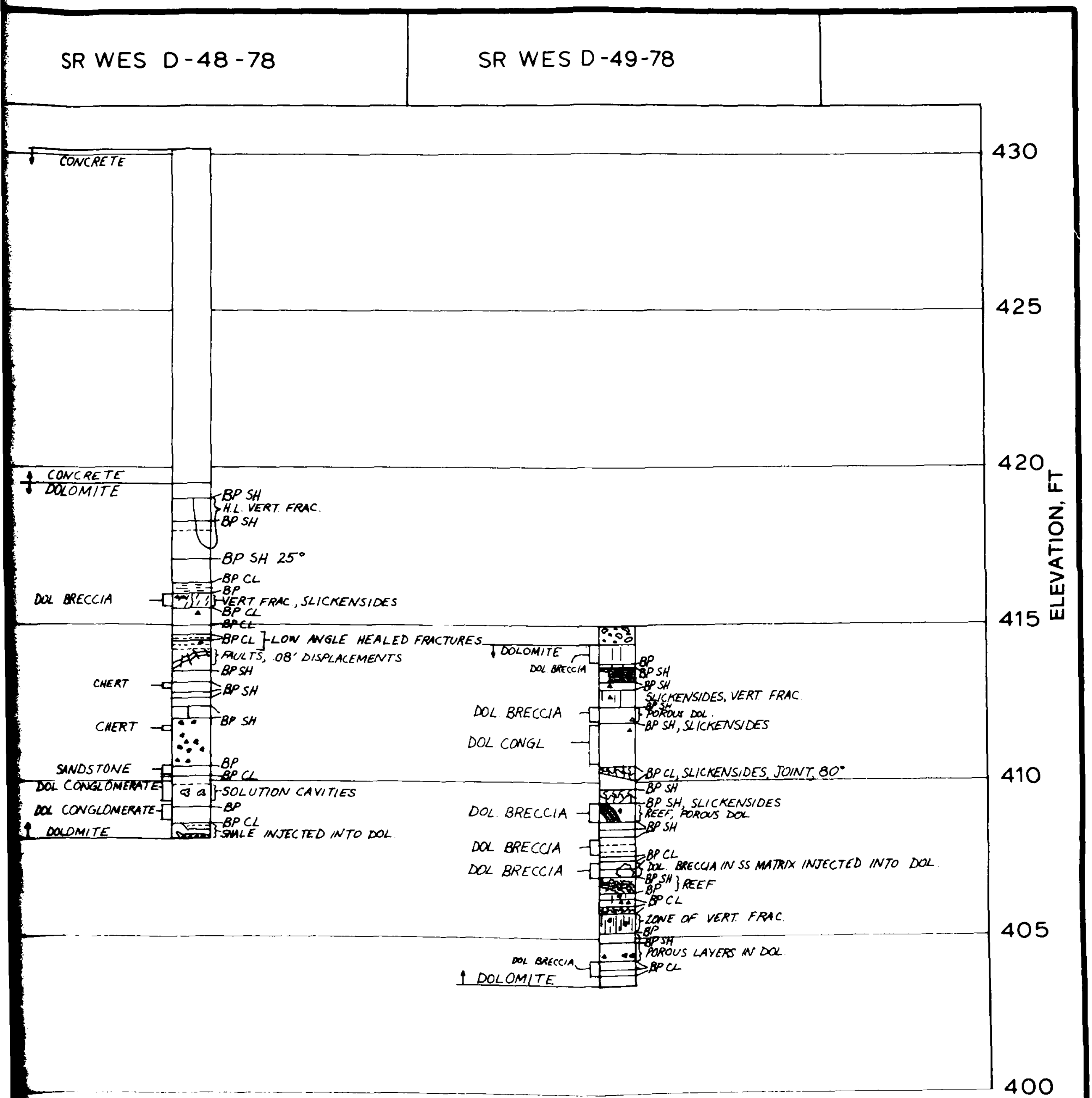


SCOUR DETECTION
STARVED ROCK LOCK AND DAM
STRUCTURE SECTION

AM


SR WES D-43-78
SR WES D-44-78
ELEVATION, FT
430
425
420
415
410
405
400
CONCRETE
CONCRETE
DOLOMITE
BP SH
POROUS, FOSS. DOL FILLING SOLUTION CAVITY
DOL CONGLOMERATE
BP
BP SH
BP CL, 25°
DOL. CONGLOMERATE
BP SH
BP SH, SLICKENSIDES
BP SH
REEF
DOL CONGLOMERATE
BP SH
BP SH
JOINT, 45°
BP
BP SH 45°
DOL. CONGLOMERATE
BP SH
BP SH
DOL CONGLOMERATE
POROUS DOL
BP WHITE CLAY
CHERT
REEF?
DOL CONGLOMERATE
SB, SLICKENSIDES
SANDSTONE
BP SH, SLICKENSIDES
DOL. INJECTED INTO BEDDED SS
BP SH, SLICKENSIDES
BP CL, SLICKENSIDES
BP SH
DOLOMITE
DOLOMITE
DOL CONGLOMERATE
BP SH SLICKENSIDES
DOL CONGLOMERATE
BP SH
BP SH
BP SH
BP SH
BP SH
DOL CONGLOMERATE
POROUS DOL
DOL. CONGLOMERATE
BP SH
BP CL
BP
BP SH
POROUS DOL, REEF
BP WHITE CLAY
DOLOMITE
POROUS DOL
DOL. CO
DOL.
DOL. C
DOL. C
PR
ST


SR WES D-45-78
SR WES D-47-78
SR WES D-48-78
CONCRETE
DOLOMITE
DOL CONGLOMERATE
DOL BRECCIA
CHERT / SS
SANDSTONE
CHERT
BP SH
BP CL
BP
JOINT, 30°, SH
30° BEDDING
POROUS DOL
VERT FRAC
DISRUPTED BEDDING
FRAC. CHERT
BP WHITE CL
SLICKENSIDES
SS
H.L. VERT
FAULTS
LEGEND
PROBABLE MISSING ZONE
STYLOLITE
VUGS
SHALE SEAM
REEF
BEDDING PLANE BREAK



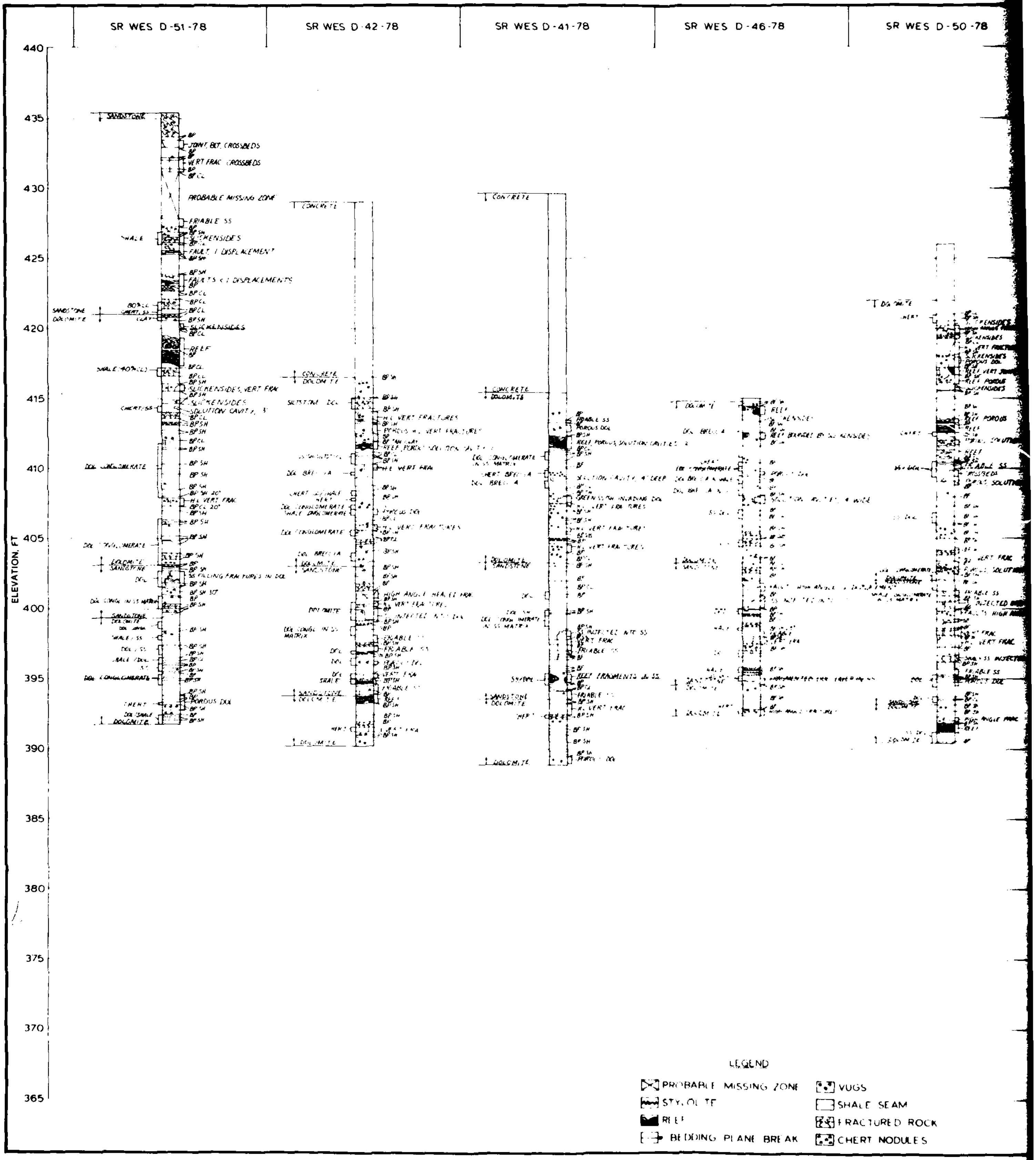
FRACTURED ROCK

BREAK

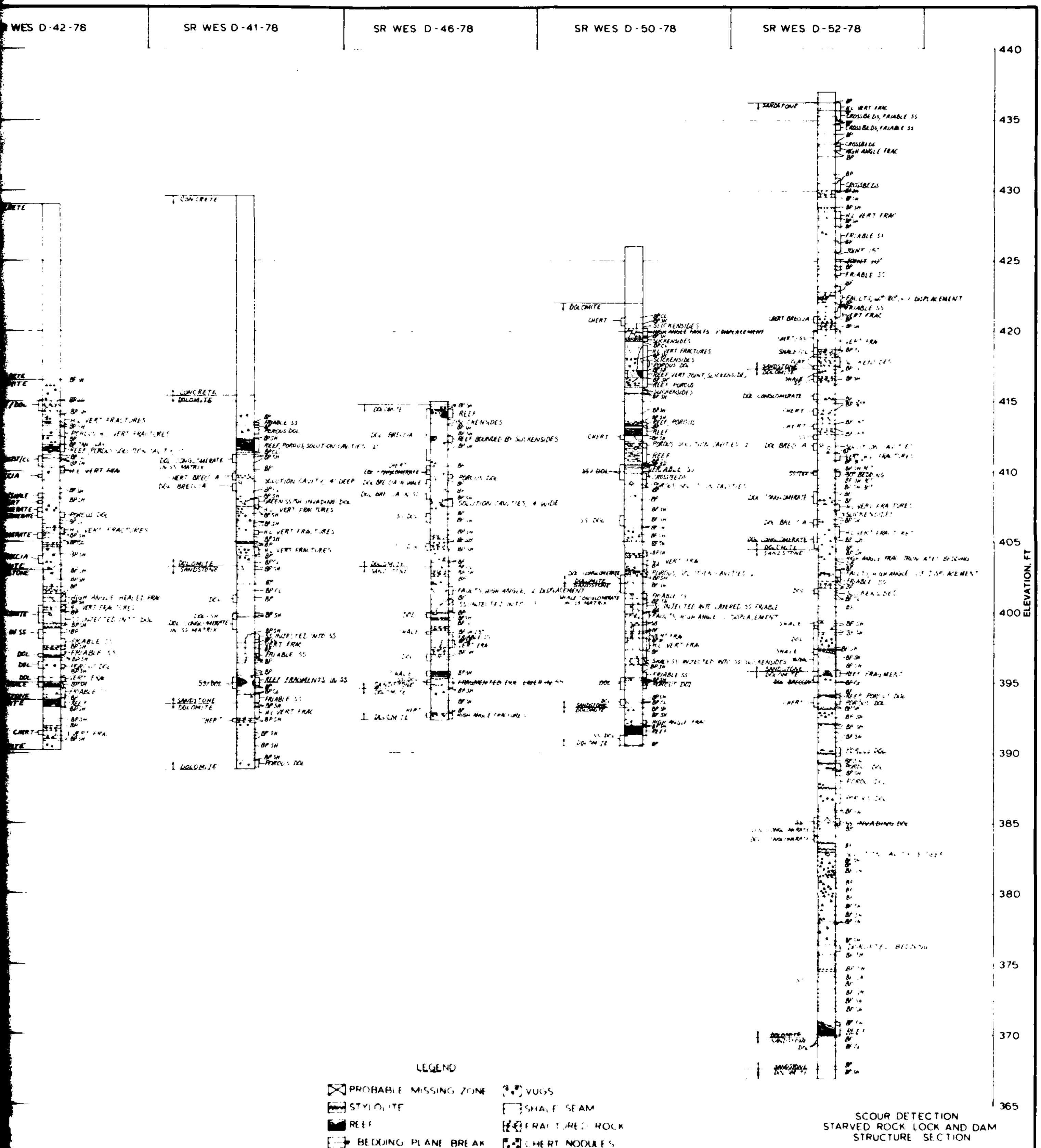
CHERT NODULES

SCOUR DETECTION
STARVED ROCK LOCK AND DAM
STRUCTURE SECTION

2



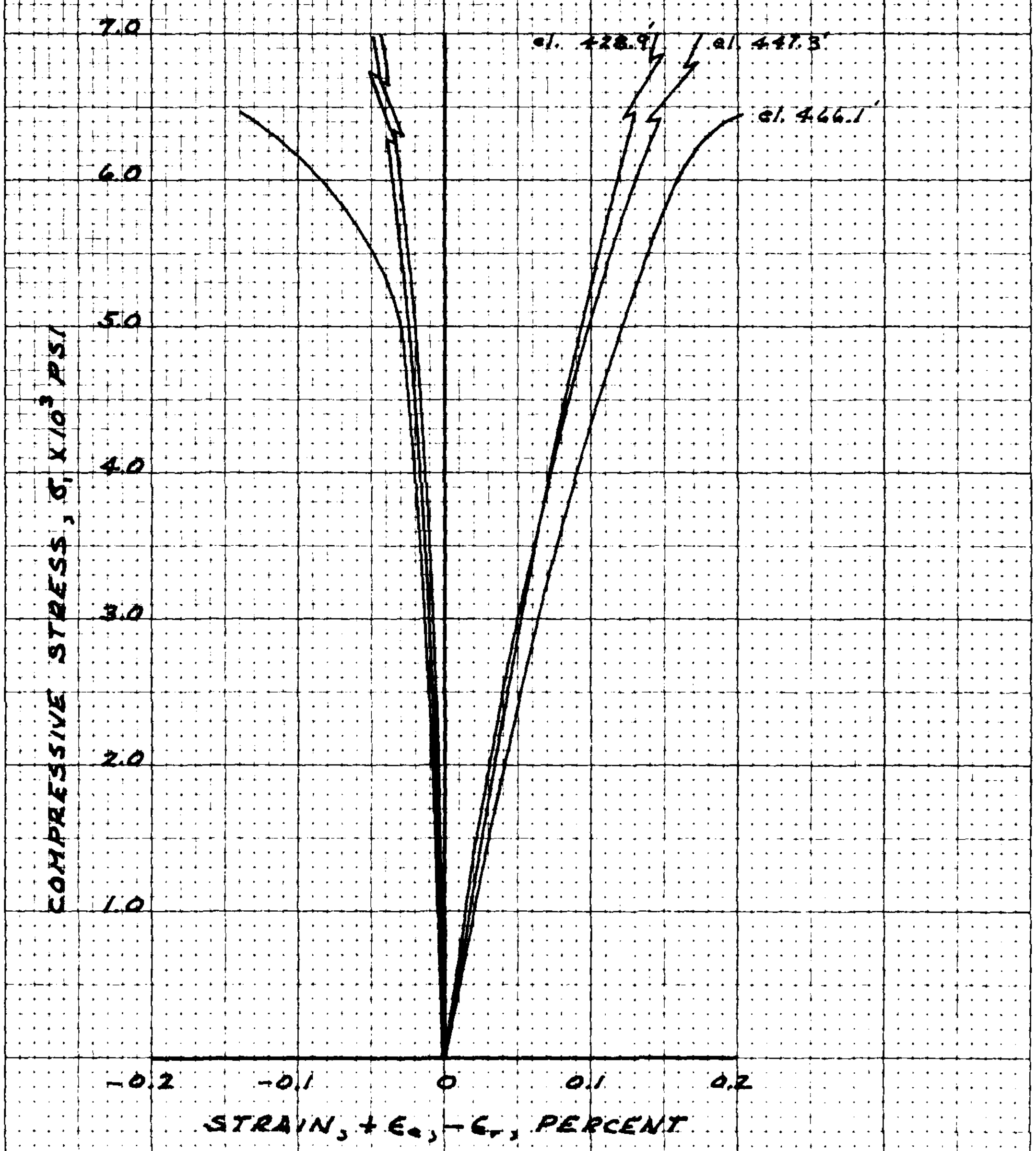
SR WES D-51-78
SR WES D-42-78
SR WES D-41-78
SR WES D-46-78
SR WES D-50-78
ELEVATION, FT
440
435
430
425
420
415
410
405
400
395
390
385
380
375
370
365
PROBABLE MISSING ZONE
LEGEND
PROBABLE MISSING ZONE
STYLOLITE
REEF
BEDDING PLANE BREAK
VUGS
SHALE SEAM
FRACTURED ROCK
CHERT NODULES



SCOUR DETECTION
STARVED ROCK LOCK AND DAM
STRUCTURE SECTION

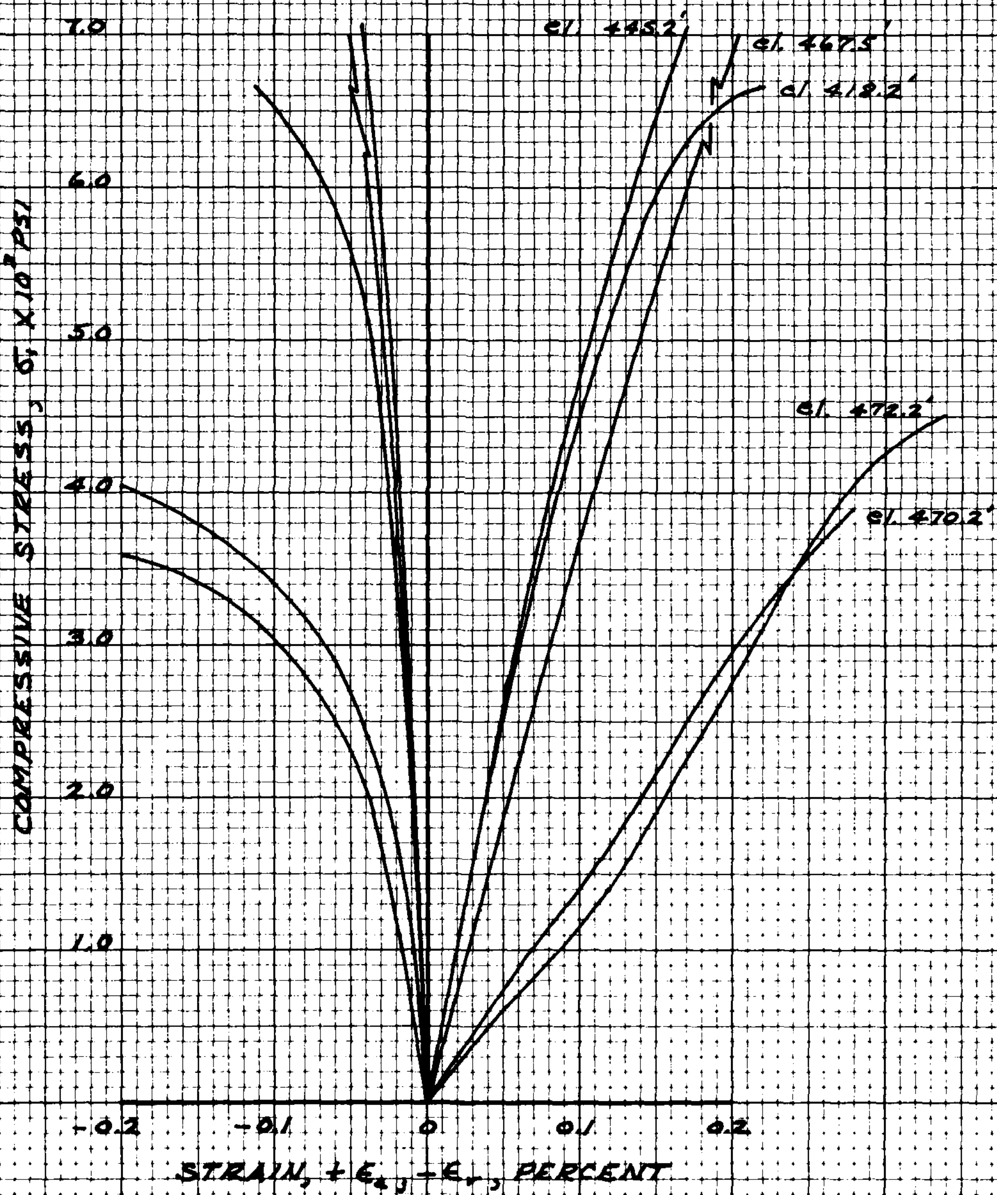
PLATE 17 2

Hole No.	Elev. FT.	σ_1 PSI	Modulus $E \times 10^6$	Poisson's Ratio	Moisture Percent
D 11	466.1	6470	5.13	0.21	5.8
D 11	447.3	7420	6.78	0.25	5.0
D 11	428.9	8410	6.67	0.17	5.3



STRESS - STRAIN RELATION FOR CONCRETE, SR LOCK AND DAM

Hole No.	Elev. Ft.	σ_1 PSI	Modulus $E \times 10^6$	Poisson's Ratio	Moisture Percent
D 12	472.2	4510	1.31	0.10	5.6
D 12	470.2	3900	1.42	0.16	4.5
D 12	467.5	8650	3.70	0.14	6.3
D 12	445.2	7080	5.00	0.19	5.2
D 12	418.2	6690	5.33	0.30	7.2



STRESS-STRAIN RELATION FOR CONCRETE, SR LOCK AND DAM

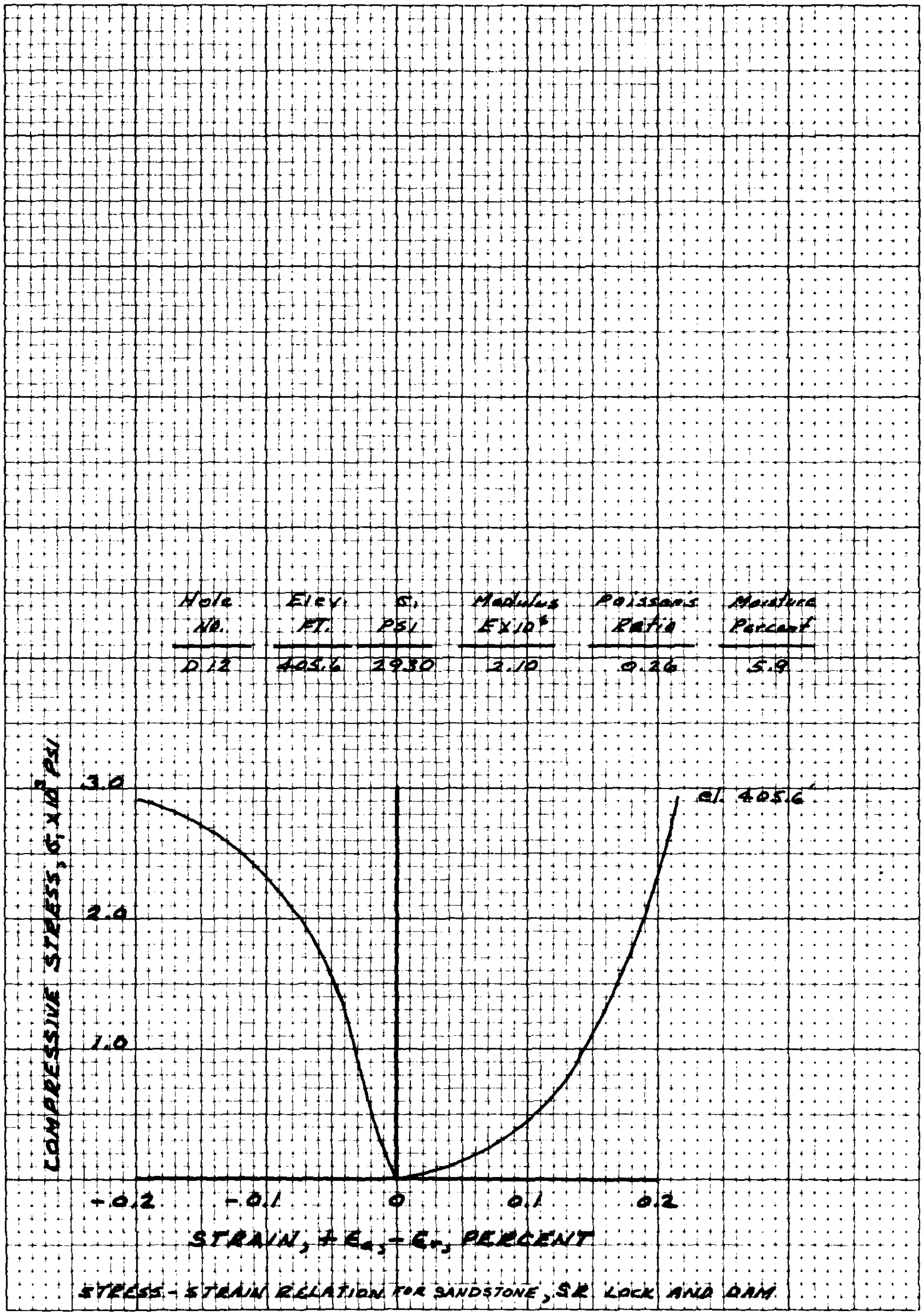
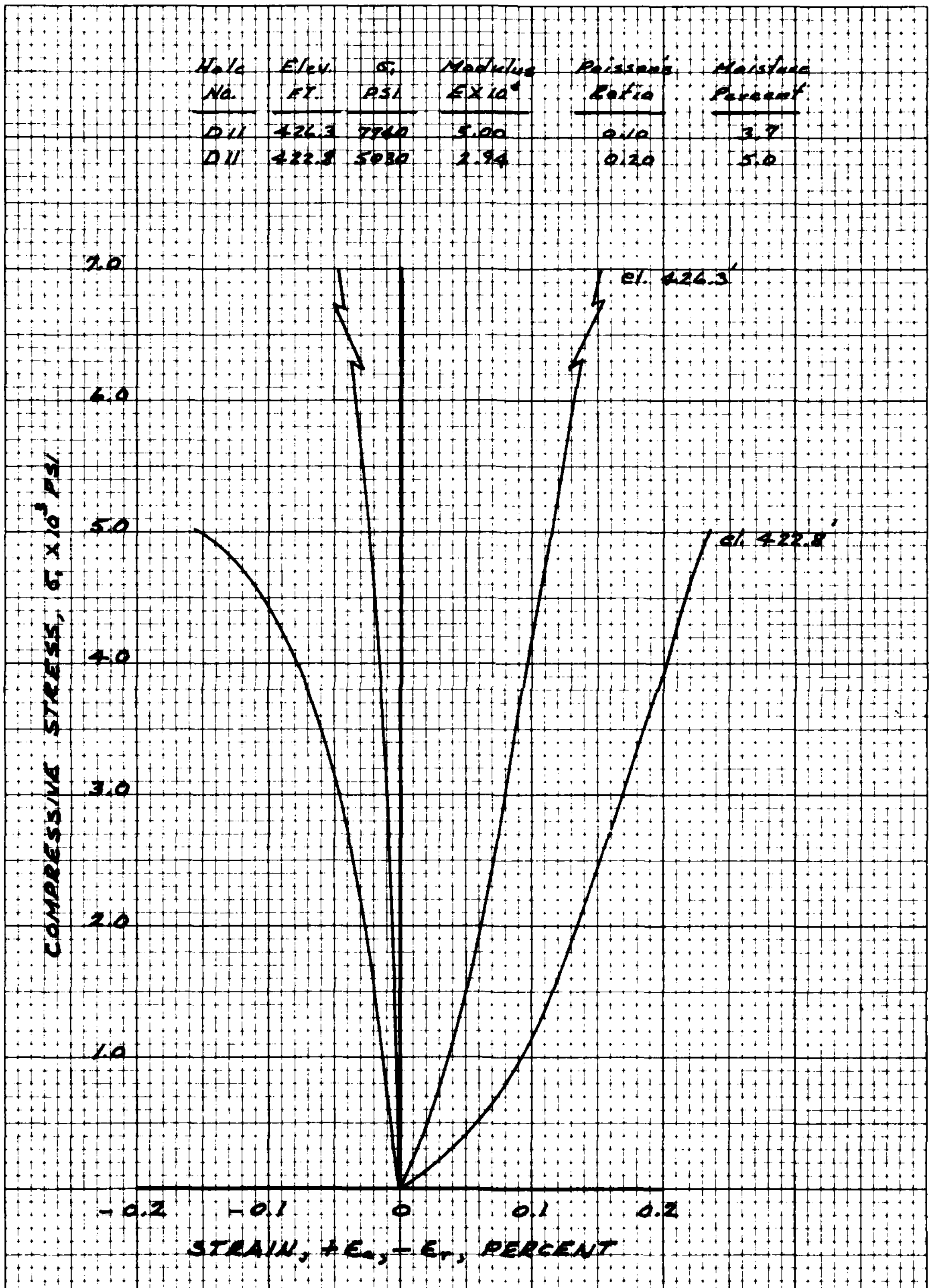

Hole No.
D12
Elev. FT.
405.6
S1 PSI
2930
Modulus E X 10^6
2.10
Poissons Ratio
0.26
Moisture Percent
5.9
COMPRESSIVE STRESS, σ1 X 10^3 PSI
3.0
2.0
1.0
el. 405.6'
-0.2
-0.1
0
0.1
0.2
STRAIN, +Ea, -Er, PERCENT
STRESS - STRAIN RELATION FOR SANDSTONE, SR LOCK AND DAM

PLATE 20



STRESS-STRAIN RELATION FOR Dolomite, SR LOCK AND DAM

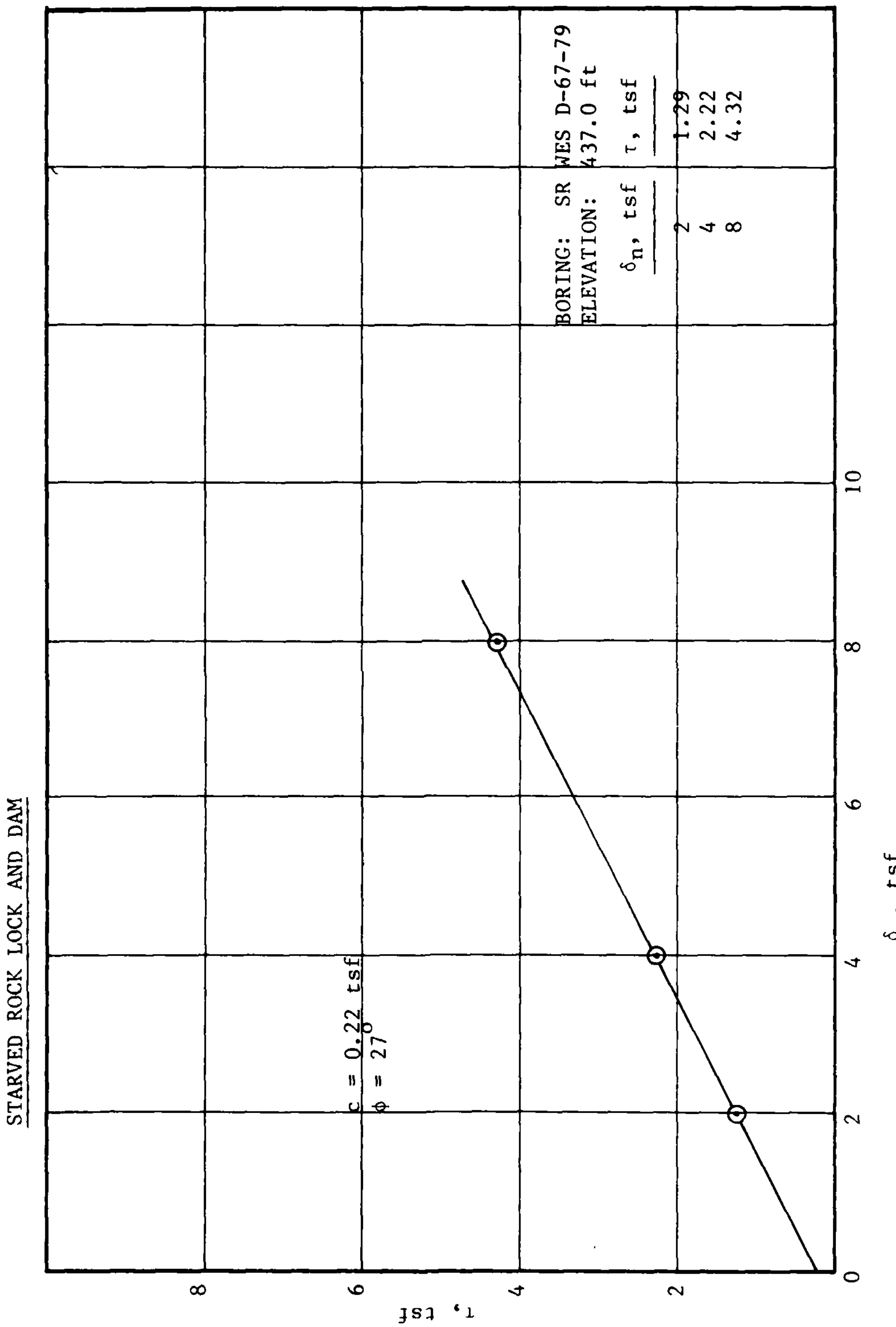


Plate 22. Direct shear of silty sand (SM), head gate dam

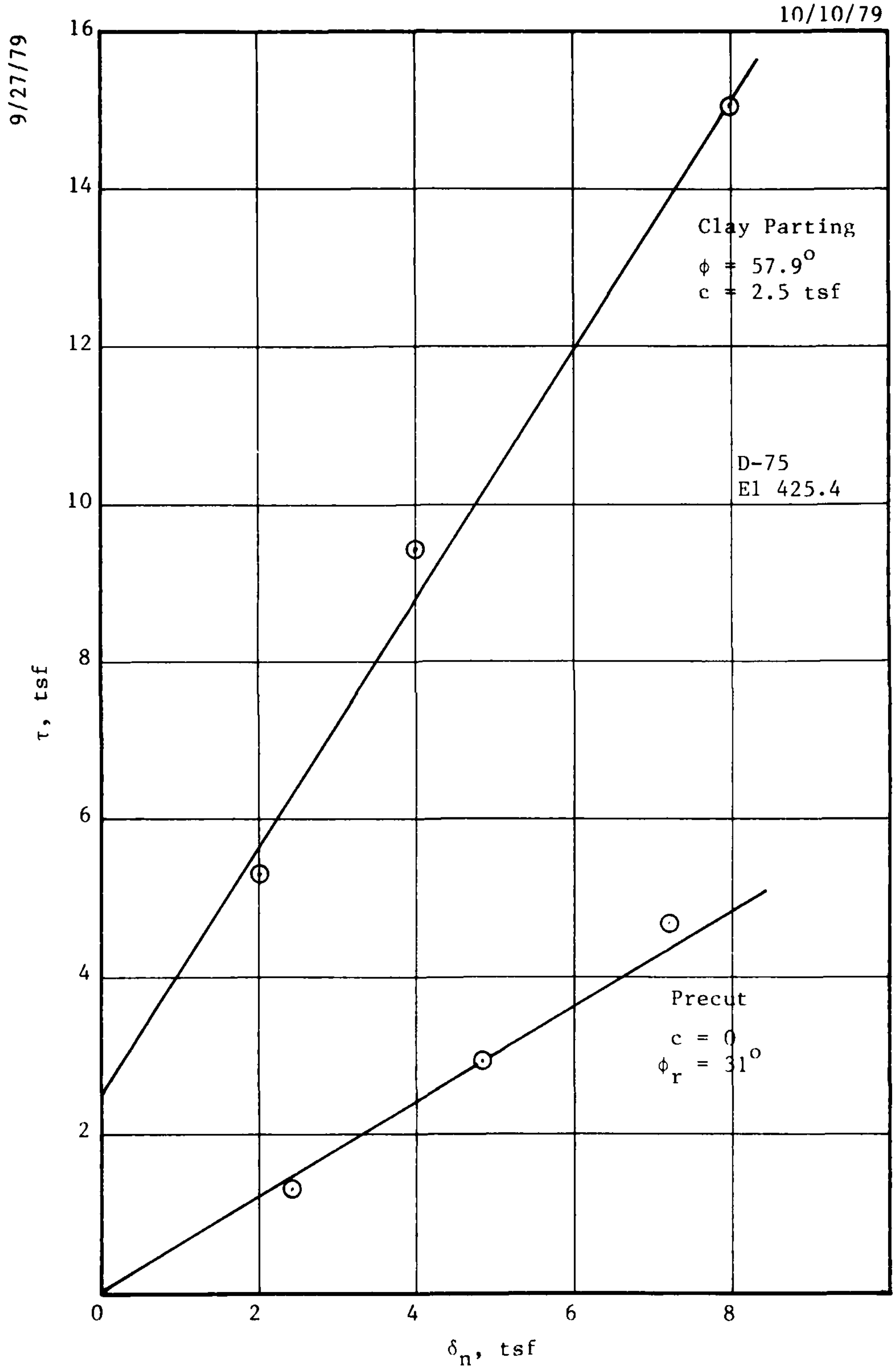
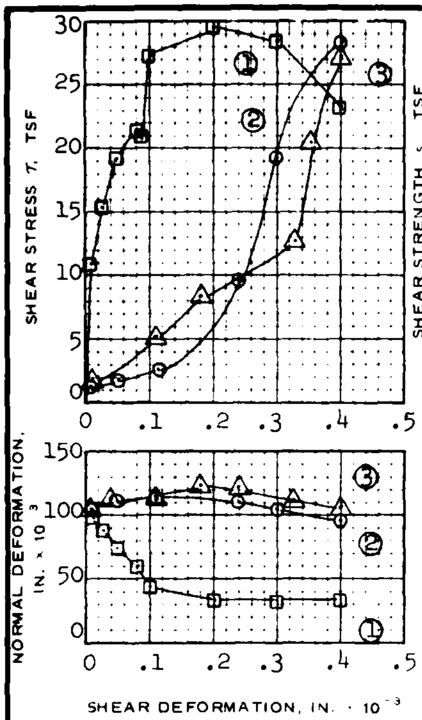
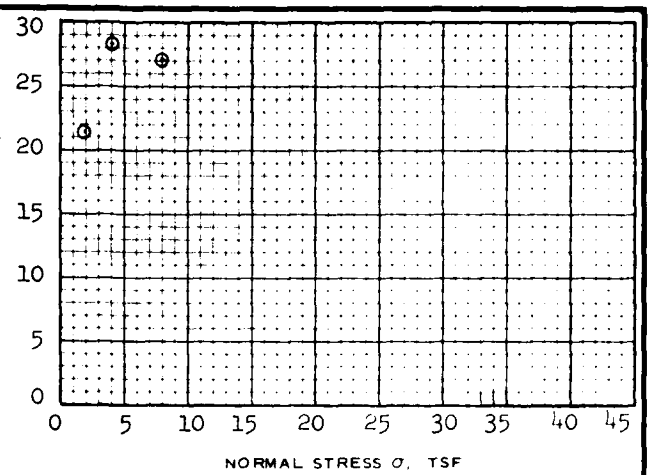


Plate 23. Multiload direct shear, clay parting competent sandstone





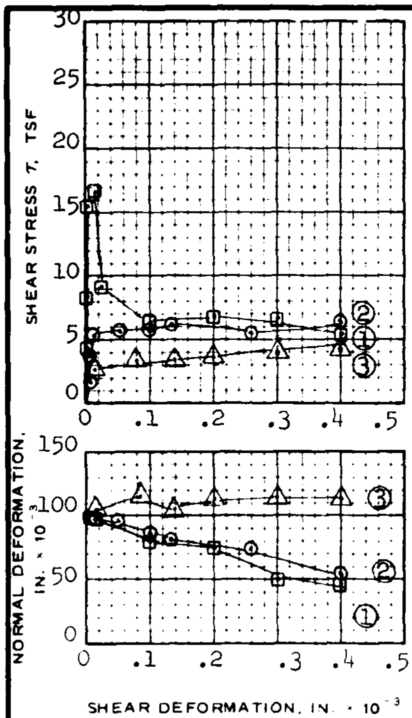
SHEAR STRENGTH PARAMETERS

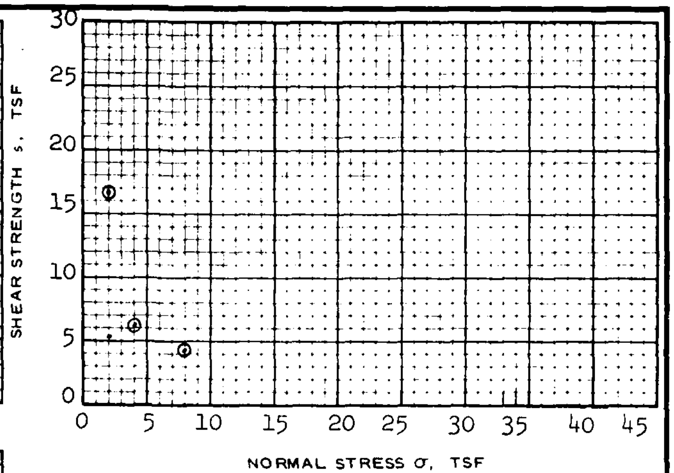
	MAXIMUM	ULTIMATE
ϕ =		
TAN ϕ =		
c =		TSF

TEST NO.		1	2	3			
WET DENSITY, PCF	γ_m	135.8	135.8	135.8			
WATER CONTENT	w	4.3 %	4.3 %	4.3 %	%	%	%
NORMAL STRESS, TSF	σ	2.0	4.0	8.0			
MAXIMUM SHEAR STRESS, TSF	τ_f	21.4	28.4	27.1			
TIME TO FAILURE, MINUTES	t_f	41	62	60			
ULTIMATE SHEAR STRESS, TSF	τ_r	23.5	28.4	27.1			
INITIAL DIAMETER, IN.	Do	5.96	5.96	5.96			
INITIAL HEIGHT, IN.	Ho						

DESCRIPTION OF MATERIAL MULTI-STAGE SHEAR; SHALE FILLED PARTINGS IN BRECCIATED DOLOMITE

REMARKS	PROJECT STARVED ROCK LOCK AND DAM
	AREA
	BORING NO. L-1 — SAMPLE NO.
	DEPTH EL 47.2 — DATE 21OCT77
	RCH DIRECT SHEAR TEST REPORT (ROCK)





SHEAR STRENGTH PARAMETERS

	MAXIMUM	ULTIMATE	
ϕ =			
TAN ϕ			
c =			TSF

TEST NO.		1	2	3			
WET DENSITY, PCF	γ_m	162.3	162.3	162.3			
WATER CONTENT	w	4.1 %	4.1 %	4.1 %	%	%	%
NORMAL STRESS, TSF	σ	2.0	4.0	8.0			
MAXIMUM SHEAR STRESS, TSF	τ_f	16.8	6.1	4.20			
TIME TO FAILURE, MINUTES	t_f	26	14	27			
ULTIMATE SHEAR STRESS, TSF	τ_r	5.4	6.4	4.2			
INITIAL AREA, IN	Do	27.95	27.88	27.88			
INITIAL HEIGHT	Ho	-	-	-			

DESCRIPTION OF MATERIAL MULTI-STAGE SHEAR OF SHALE FILLED PARTINGS IN DOLOMITE

REMARKS

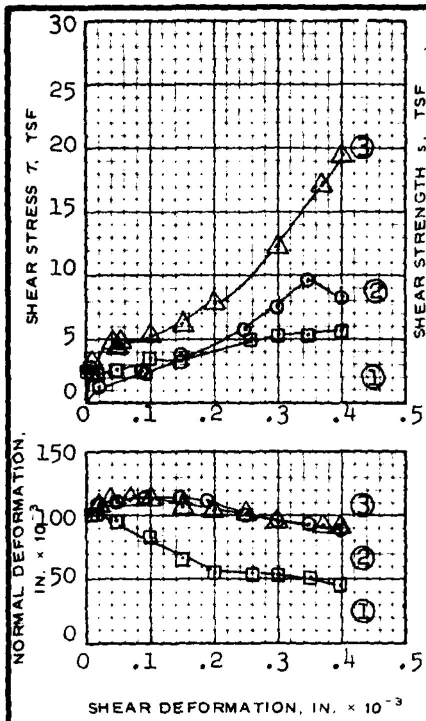
PROJECT STARVED ROCK LOCK AND DAM

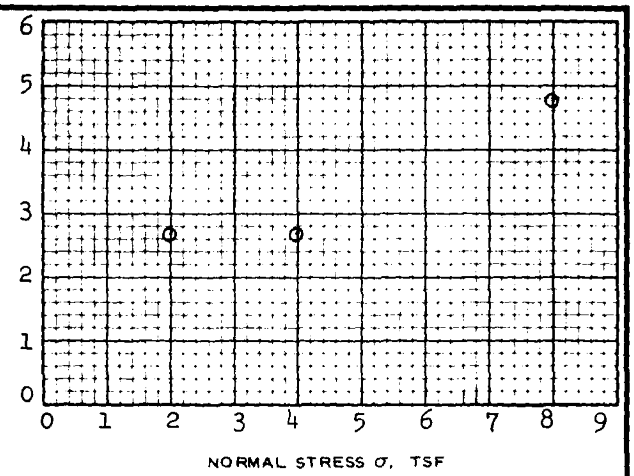
AREA

BORING NO. D-12 | SAMPLE NO.

DEPTH EL 75.9 | DATE 01 DEC 77

TFS DIRECT SHEAR TEST REPORT (ROCK)





SHEAR STRENGTH PARAMETERS

	MAXIMUM	ULTIMATE
ϕ =		
TAN ϕ =		
c =		TSF

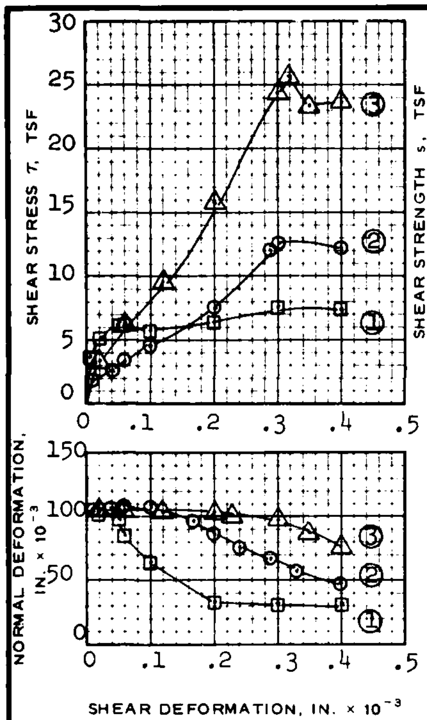
TEST NO.		1	2	3			
WET DENSITY, PCF	γ_m	163.9	163.9	163.9			
WATER CONTENT	w	6.7 %	6.7 %	6.7 %	%	%	%
RATE OF STRAIN INCREASED AT		0.155	0.156	-			
NORMAL STRESS, TSF	σ	2.0	4.0	8.0			
MAXIMUM SHEAR STRESS, TSF	τ_f	2.7	2.7	4.8			
TIME TO FAILURE, MINUTES	t_f	7	35	10			
ULTIMATE SHEAR STRESS, TSF	τ_r	5.8	8.3	19.7			
INITIAL DIAMETER, IN.	Do	5.97	5.97	5.97			
INITIAL HEIGHT, IN.	Ho						

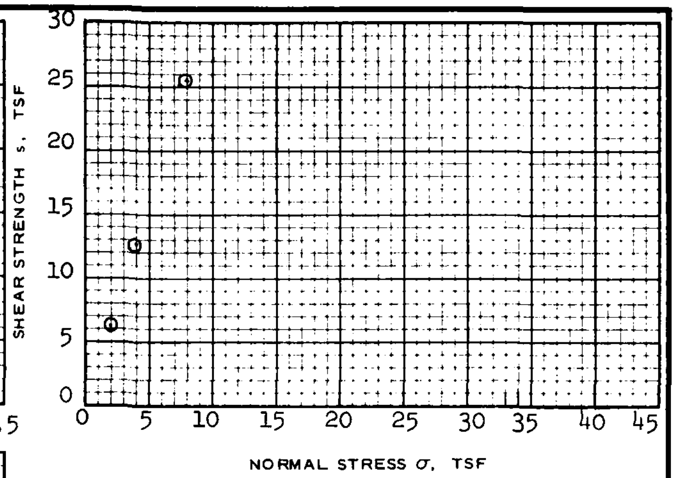
DESCRIPTION OF MATERIAL MULTI-STAGE SHEAR;SHALE FILLED PARTINGS IN BRECCIATED DOLOMITE

REMARKS

PROJECT STARVED ROCK LOCK AND DAM	
AREA	
BORING NO. GW-2	SAMPLE NO.
DEPTH EL 42.7	DATE 09SEP77
RCH DIRECT SHEAR TEST REPORT (ROCK)	

PLATE 26





SHEAR STRENGTH PARAMETERS

	MAXIMUM	ULTIMATE
ϕ =		
TAN ϕ =		
c =		TSF

TEST NO.		1	2	3			
WET DENSITY, PCF	γ_m	147.1	147.1	147.1			
WATER CONTENT	w	7.7 %	7.7 %	7.7 %	%	%	%
RATE OF STRAIN INCREASED AT		0.06	0.33	0.35			
NORMAL STRESS, TSF	σ	2.0	4.0	8.0			
MAXIMUM SHEAR STRESS, TSF	τ_f	6.3	12.8	25.6			
TIME TO FAILURE, MINUTES	t_f	69	61	58			
ULTIMATE SHEAR STRESS, TSF	τ_r	7.4	12.2	23.6			
INITIAL DIAMETER, IN.	Do	5.98	5.98	5.98			
INITIAL HEIGHT, IN.	Ho						

DESCRIPTION OF MATERIAL: MULTI-STAGE SHEAR; SHALE FILLED PARTINGS IN BRECCIATED DOLOMITE

REMARKS

PROJECT: STARVED ROCK LOCK AND DAM

AREA

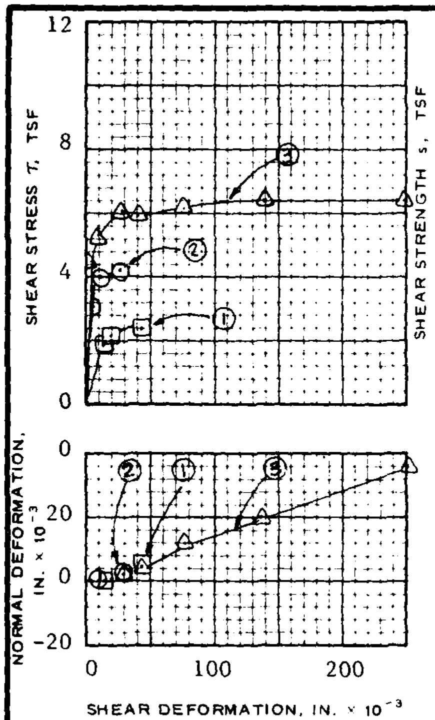
BORING NO.: D-15 | SAMPLE NO.

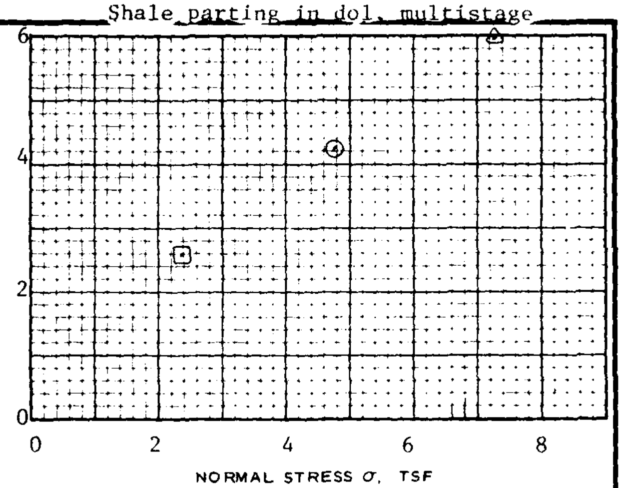
DEPTH EL: 18.4 | DATE

RCH DIRECT SHEAR TEST REPORT (ROCK)

WES FORM APR 72 1490 EDITION OF JUN 65 IS OBSOLETE

Shale parting in dol. multistage





SHEAR STRENGTH PARAMETERS

	MAXIMUM	ULTIMATE	
ϕ =			
TAN ϕ =			
c =			TSF

TEST NO.		1	2	3			
WET DENSITY, PCF	γ_d						
WATER CONTENT	w	2.6 %	%	%	%	%	%
NORMAL STRESS, TSF	σ	2.37	4.75	7.20			
MAXIMUM SHEAR STRESS, TSF	τ_f	2.56	4.28	6.03			
TIME TO FAILURE, MINUTES	t_f	25	12	9			
ULTIMATE SHEAR STRESS, TSF	τ_r						
INITIAL Area, sq in.	Do	23.87					
INITIAL HEIGHT, IN.	Ho						

DESCRIPTION OF MATERIAL Shale parting in dolomite - multistage

REMARKS

Shape of
Specimen

PROJECT

AREA

BORING NO. CSR-2

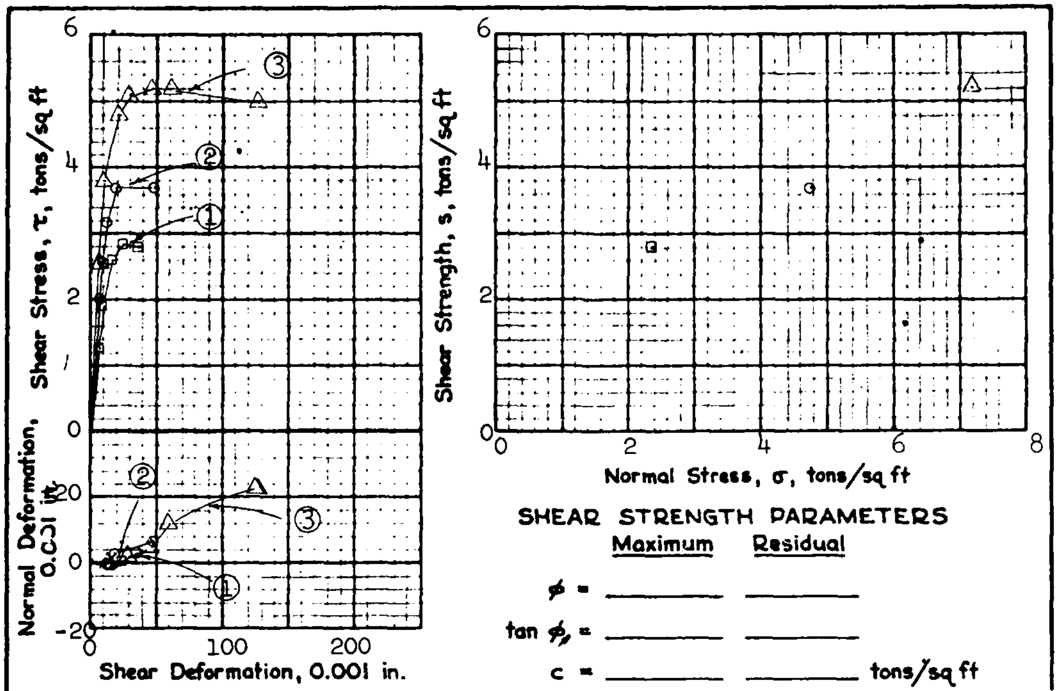
SAMPLE NO.

DEPTH EL 401.6 ft

DATE 13 Jan 1975

DIRECT SHEAR TEST REPORT (ROCK)

PLATE 28



SHEAR STRENGTH PARAMETERS

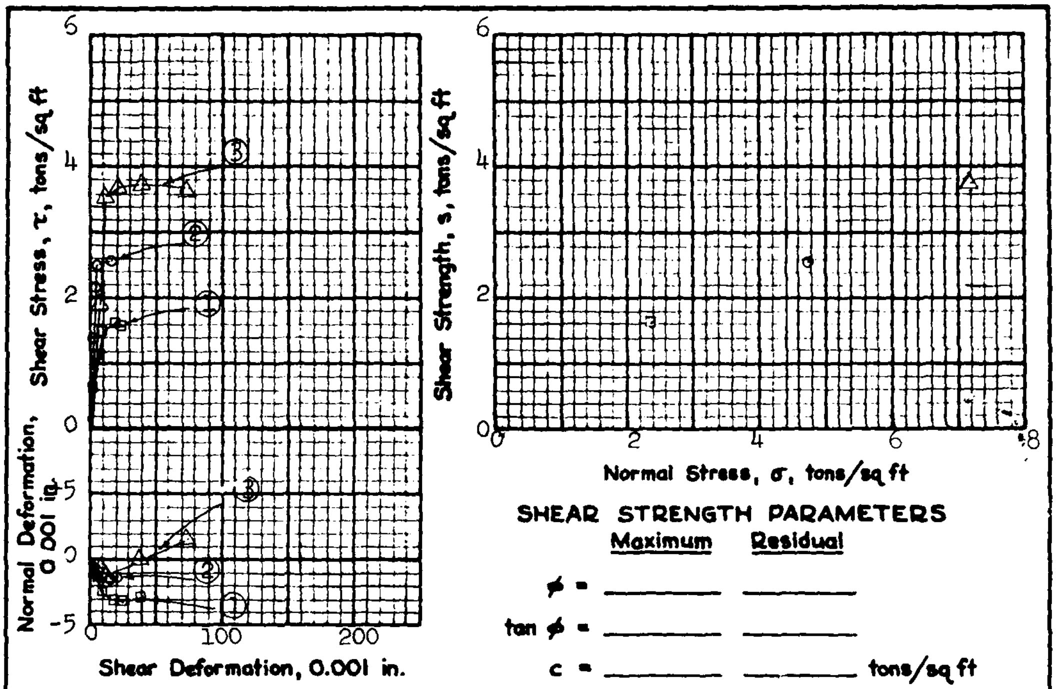
	Maximum	Residual	
ϕ =			
tan ϕ =			
c =			tons/sq ft

Test No.		1	2	3			
Wet density, lb/cu ft	γ_d						
Water content	w	4.9 %	%	%	%	%	%
Normal stress, tons/sq ft	σ	2.37	4.75	7.20			
Maximum shear stress, tons/sq ft	τ_f	2.83	3.69	5.22			
Time to failure, minutes	t_f	5	4	5			
Residual shear stress, tons/sq ft	τ_r						
Initial Diameter, Inches	Do	6.00					
Initial Height, Inches	Ho						

Description of material SHALE PARTING IN DOLOMITE - Multistage

Remarks	Project
	Area
	Boring No. CSR - 8 / Sample No.
	Depth El 426.7 / Date 13 Jan. 1975

DIRECT SHEAR TEST REPORT (ROCK)



SHEAR STRENGTH PARAMETERS

	Maximum	Residual	
ϕ =			
tan ϕ =			
c =			tons/sq ft

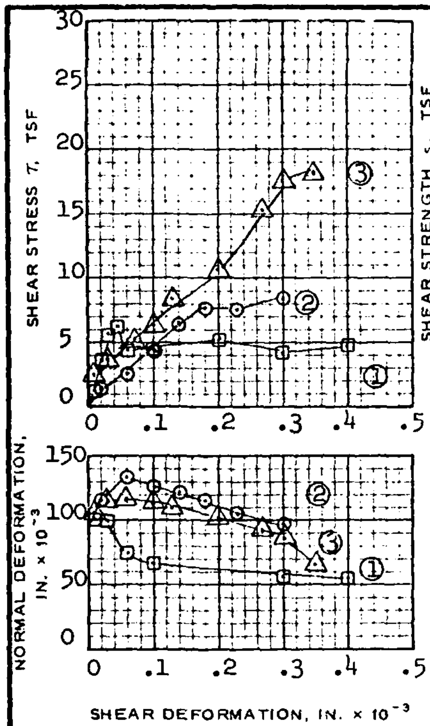
Test No.		1	2	3			
Wet density, lb/cu ft	γ_d						
Water content	w	4.9 %	%	%	%	%	%
Normal stress, tons/sq ft	σ	2.37	4.75	7.20			
Maximum shear stress, tons/sq ft	τ_f	1.61	2.56	3.72			
Time to failure, minutes	t_f	5	9	8			
Residual shear stress, tons/sq ft	τ_r						
Initial Diameter, Inches	Do	5.98					
Initial Height, Inches	Ho						

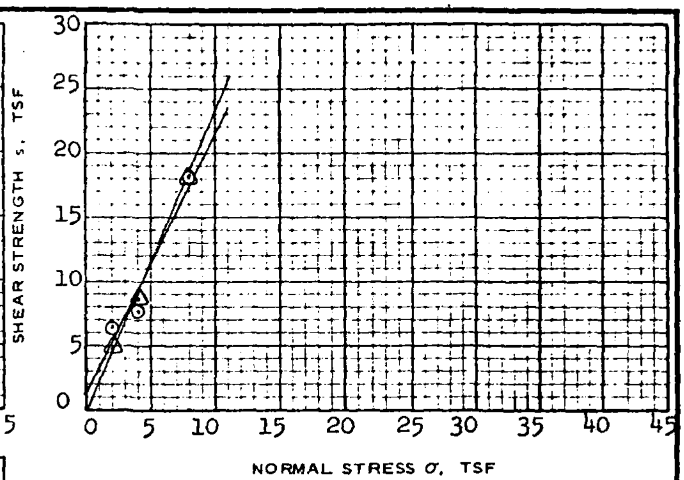
Description of material SHALE PARTING IN DOLOMITE
Multistage

Remarks

Project	
Area	
Boring No. CSR 4	Sample No.
Depth El 418.1	Date 14 Jan. 1975

DIRECT SHEAR TEST REPORT (ROCK)





SHEAR STRENGTH PARAMETERS

⊙ MAXIMUM ULTIMATE △

ϕ = ________ ________

TAN ϕ = ________ ________

c = ________ ________ TSF

TEST NO.		1	2	3			
WET DENSITY, PCF	γ_m	162.8	162.8	162.8			
WATER CONTENT	w	5.0 %	5.0 %	5.0 %	%	%	%
NORMAL STRESS, TSF	σ	2.0	4.0	8.0			
MAXIMUM SHEAR STRESS, TSF	τ_f	6.3	7.8	18.1			
TIME TO FAILURE, MINUTES	t_f	19	11	25			
ULTIMATE SHEAR STRESS, TSF	τ_r	4.9	8.4	18.1			
INITIAL AREA, IN	Do	27.90	27.88	27.88			
INITIAL HEIGHT, IN.	Ho	-	-	-			

DESCRIPTION OF MATERIAL MULTI-STAGE SHEAR OF SHALE FILLED PARTINGS IN DOLOMITE

REMARKS

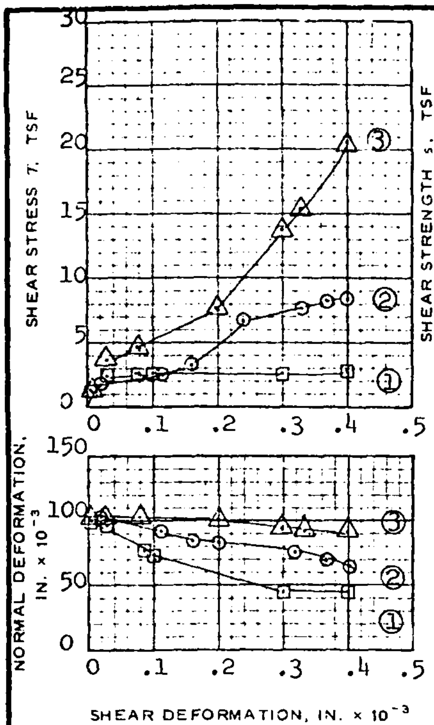
PROJECT STARVED ROCK LOCK AND DAM

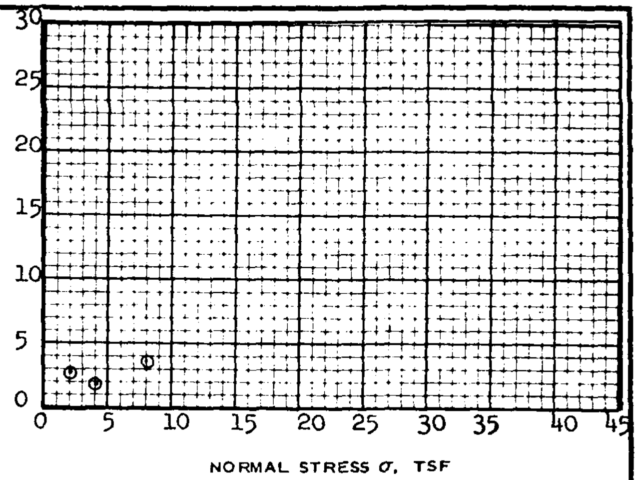
AREA

BORING NO. D-12 SAMPLE NO.

DEPTH/EL 63.2/409.5 DATE 30 NOV 77

TES DIRECT SHEAR TEST REPORT (ROCK)





SHEAR STRENGTH PARAMETERS

⊙ MAXIMUM ULTIMATE △

ϕ = ______ ______

TAN ϕ = ______ ______

c = ______ ______ TSF

TEST NO.		1	2	3			
WET DENSITY, PCF	γ_m	142.6	142.6	142.6			
WATER CONTENT	w	5.6 %	5.6 %	5.6 %	%	%	%
NORMAL STRESS, TSF	σ	2.0	4.0	8.0			
MAXIMUM SHEAR STRESS, TSF	τ_f	2.7	1.8	3.7			
TIME TO FAILURE, MINUTES	t_f	17	26	8			
ULTIMATE SHEAR STRESS, TSF	τ_r	3.0	8.2	20.7			
INITIAL AREA, IN	Do	27.83	27.83	27.83			
INITIAL HEIGHT, IN.	Ho	-	-	-			

DESCRIPTION OF MATERIAL MULTI-STAGE SHEAR OF SHALE FILLED PARTINGS IN DOLOMITE

REMARKS

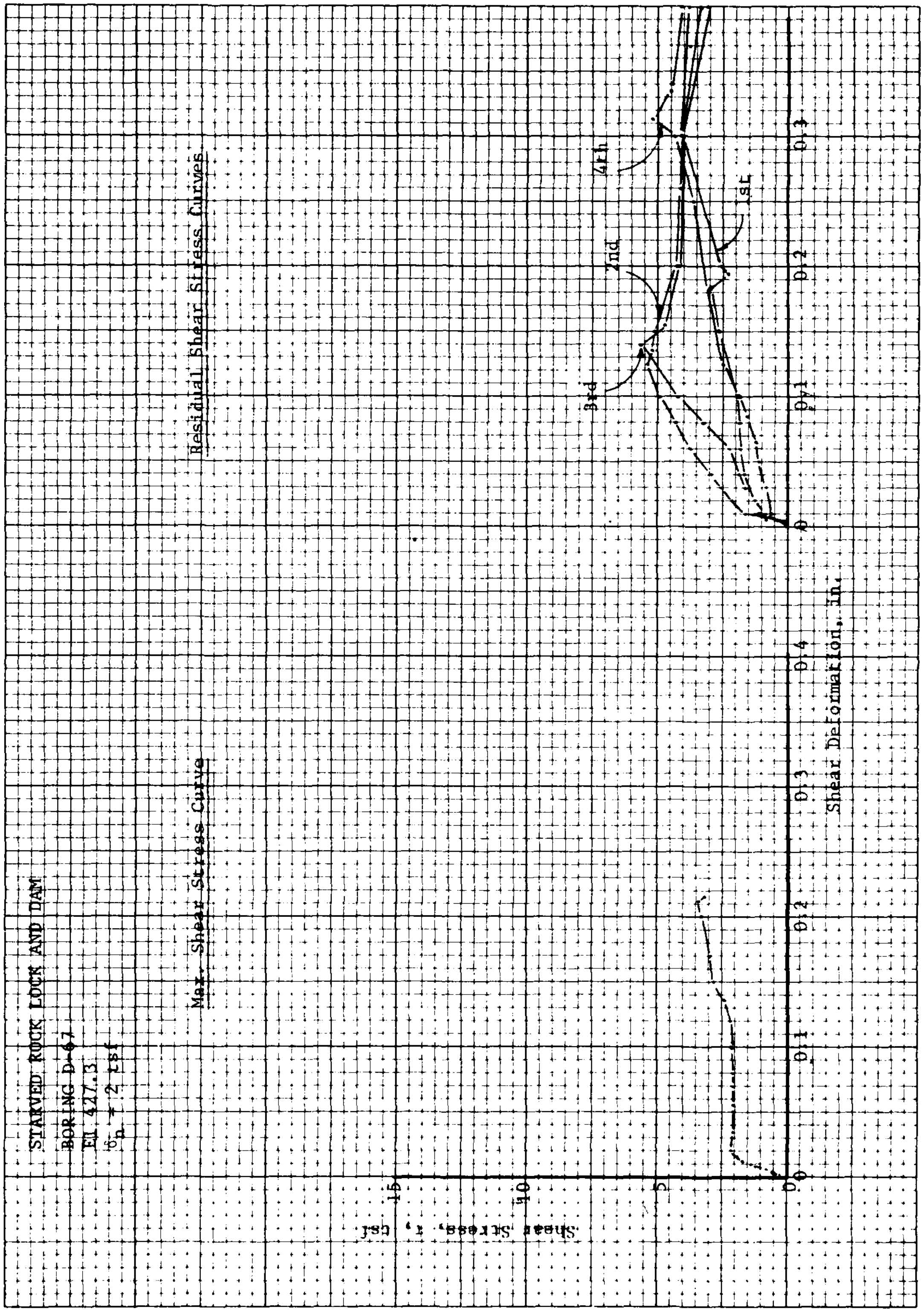
PROJECT STARVED ROCK LOCK AND DAM

AREA

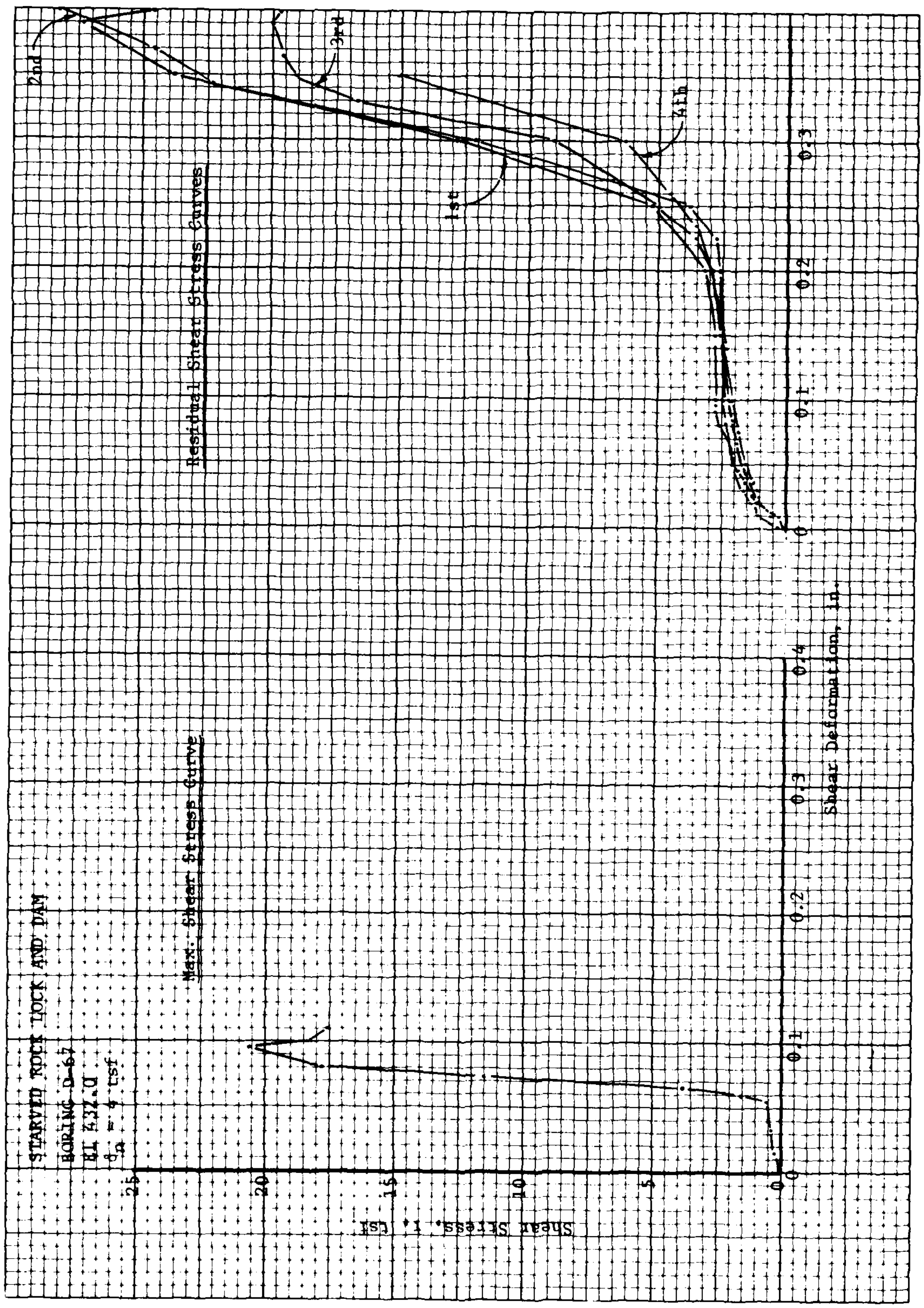
BORING NO. D-11 SAMPLE NO.

DEPTH / EL 53.8/415.2 DATE 14 NOV 7

TES DIRECT SHEAR TEST REPORT (ROCK)



Direct shear test, shale parting in dolomite, δ_n = 2 tsf



Direct shear test, shale parting in dolomite, δ_n = 4 tsf

PLATE 34

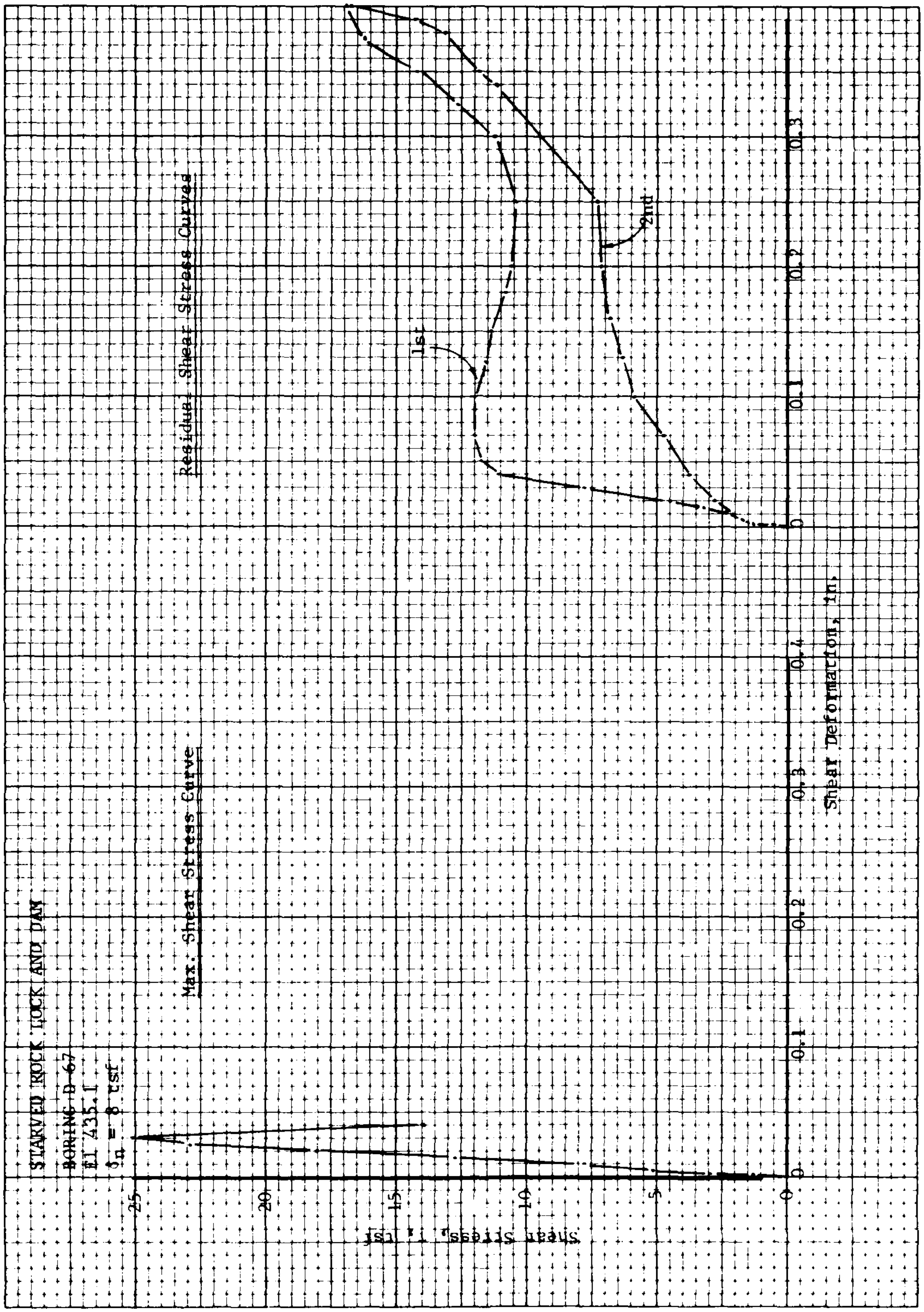


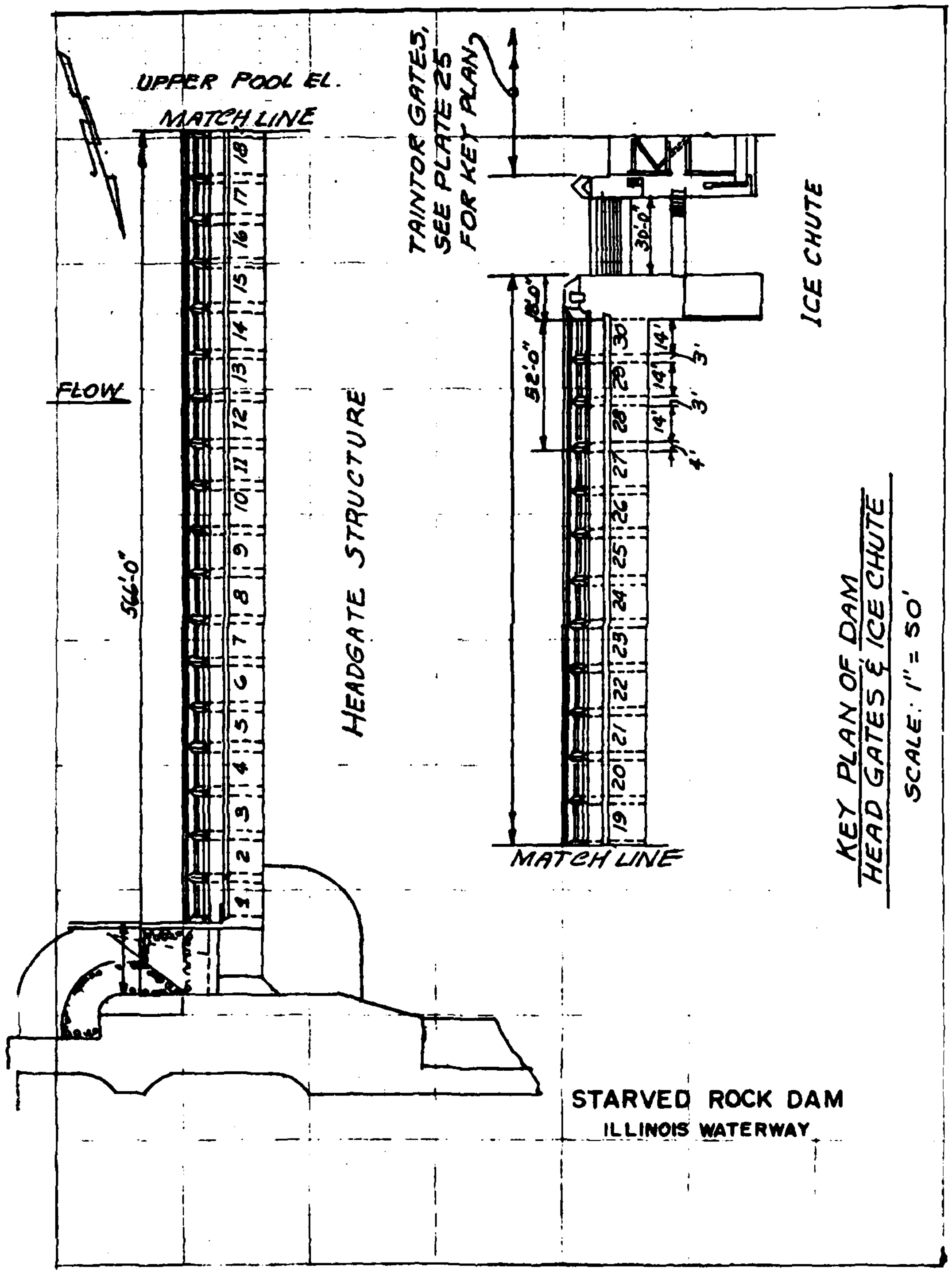
Plate 35. Direct shear test, shale parting in dolomite σ_n = 8 tsf

APPENDIX A

SCOUR PROFILES FROM

CHICAGO DISTRICT

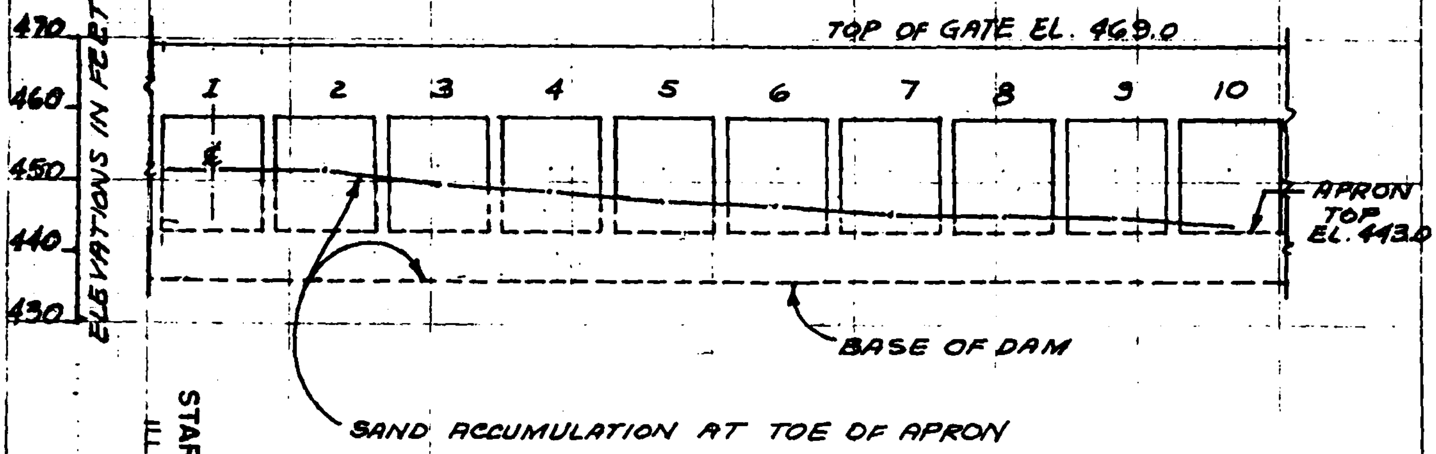
STARVED ROCK LOCK AND DAM



STARVED ROCK DAM
ILLINOIS WATERWAY

GENERAL NOTES:

1. GROUND ELEVATION BASED ON SURVEY OF JUNE, 1977.
2. FOR GATES 1 THROUGH 14, BECAUSE OF HIGH GROUND DOWNSTREAM OF THE DAM, GROUND ELEVATIONS ONLY AT THE TOE OF THE APRON WERE SURVEYED. FOR GATES 15 THROUGH 30, AND THE ICE CHUTE, WHERE THE GROUND IS LOWER, CROSS-SECTIONS WERE TAKEN DOWNSTREAM OF THE DAM.

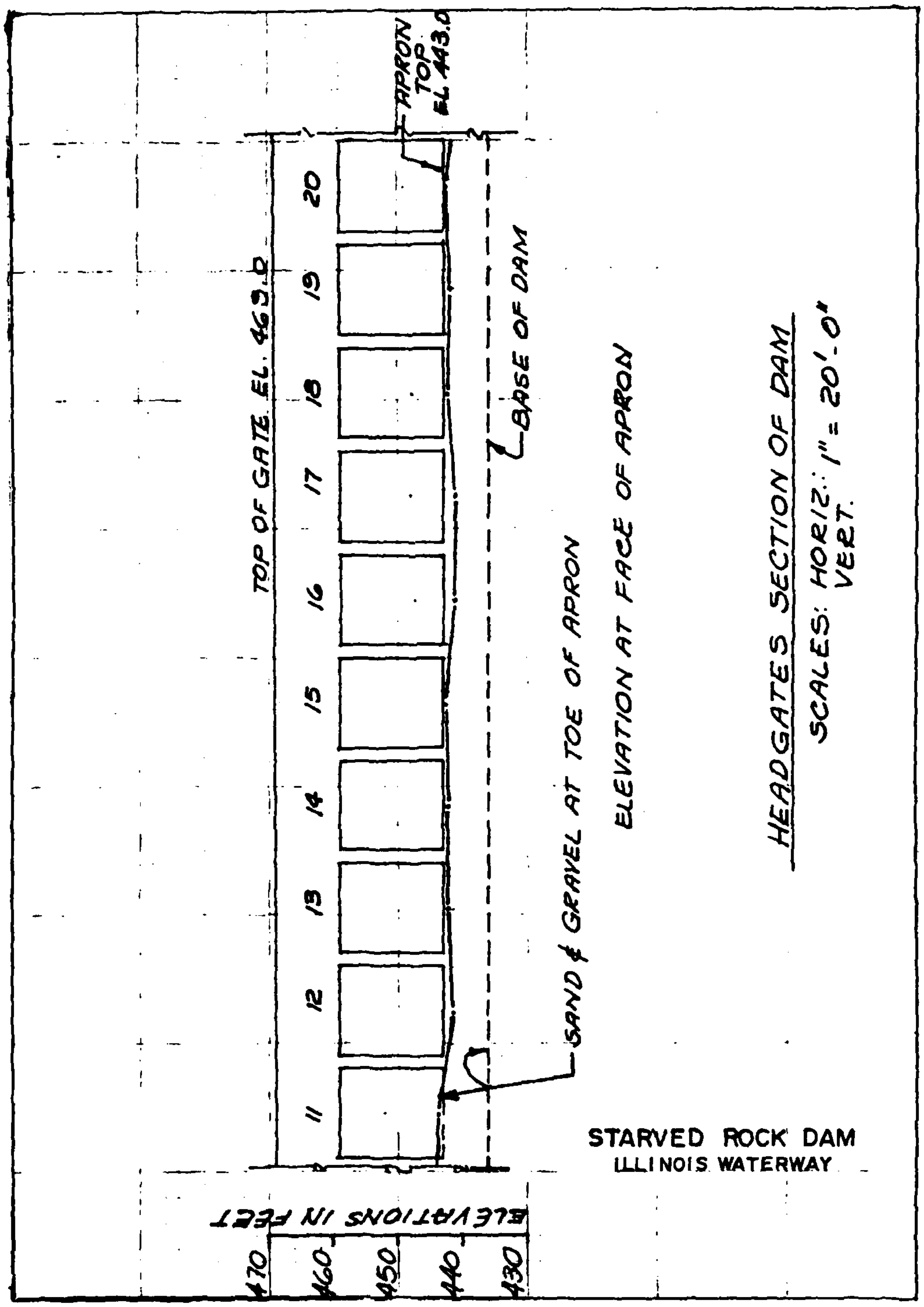


STARVED ROCK DAM
ILLINOIS WATERWAY

DOWNSTREAM ELEVATION - HEADGATES SECTION OF DAM

SCALE: HORIZ. & VERT. 1" = 20'-0"

PLATE A2



STARVED ROCK DAM
ILLINOIS WATERWAY

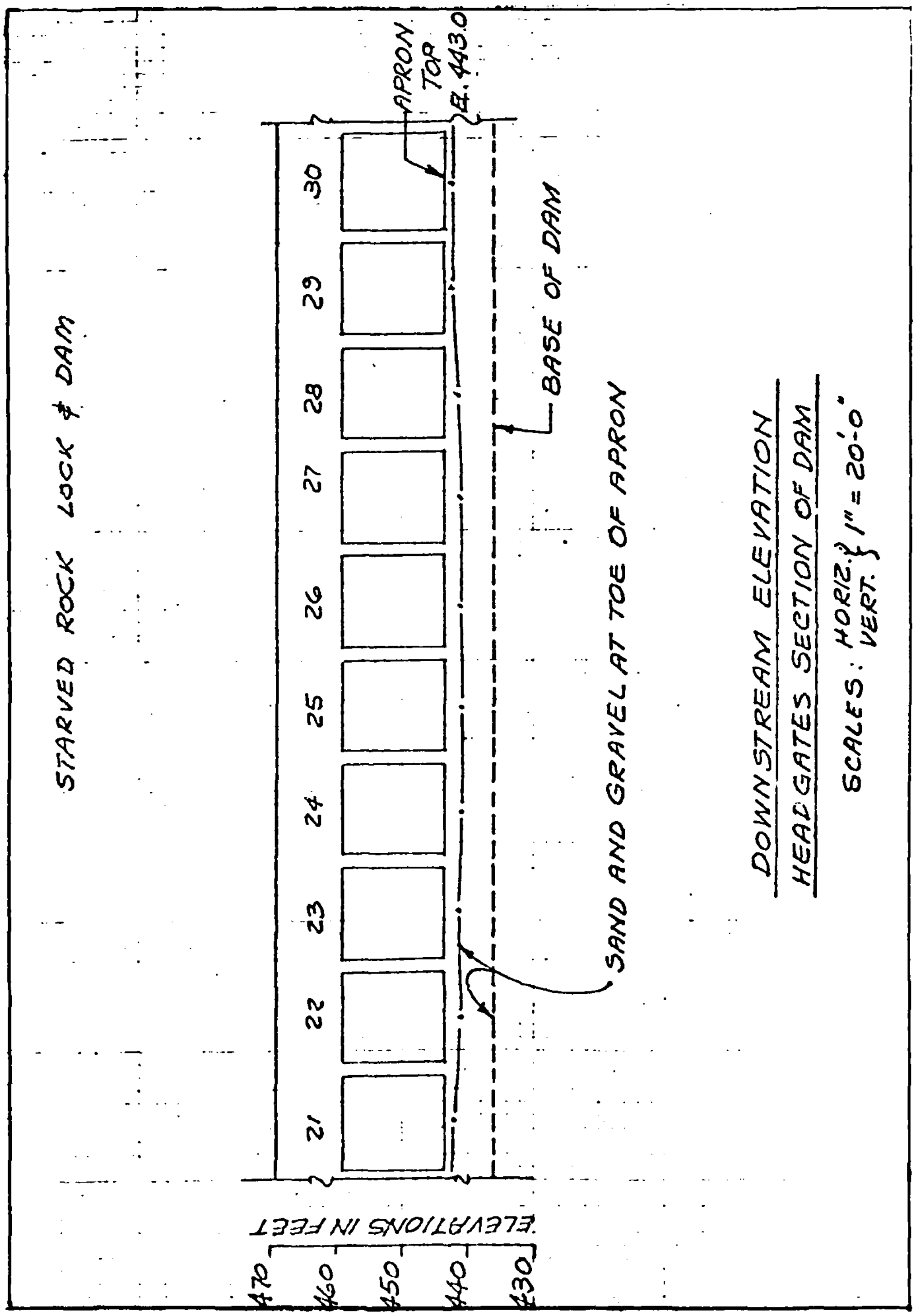
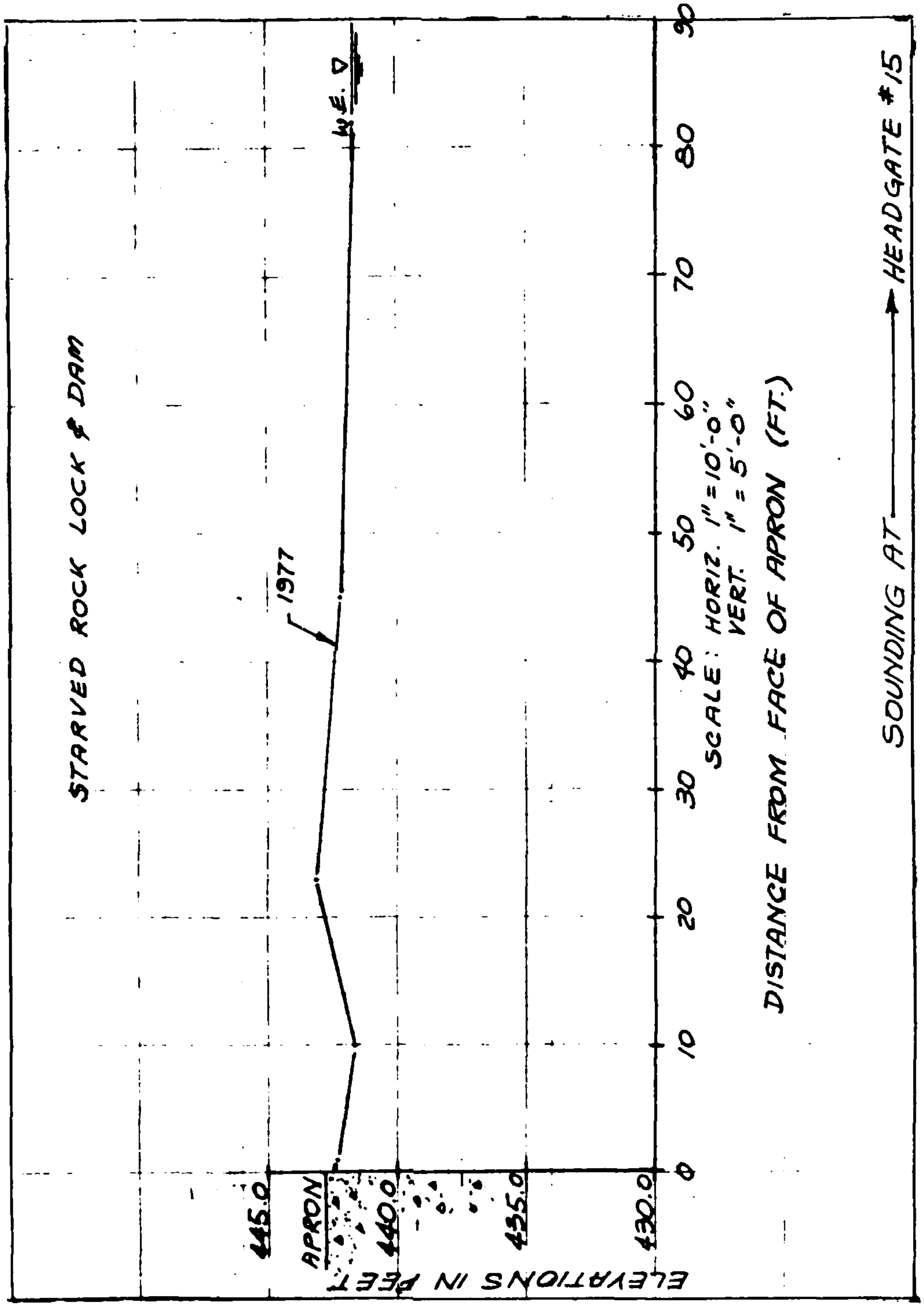

STARVED ROCK LOCK & DAM
APRON TOP EL. 443.0
BASE OF DAM
SAND AND GRAVEL AT TOE OF APRON
21
22
23
24
25
26
27
28
29
30
ELEVATIONS IN FEET
470
460
450
440
430
DOWNSTREAM ELEVATION
HEADGATES SECTION OF DAM
SCALES: HORIZ. } 1" = 20'-0"
VERT.

PLATE A4


STARVED ROCK LOCK & DAM
1977
W.E. ∇
SCALE: HORIZ. 1"=10'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
SOUNDING AT → HEADGATE #15
0
10
20
30
40
50
60
70
80
90
ELEVATIONS IN FEET
445.0
440.0
435.0
430.0
APRON

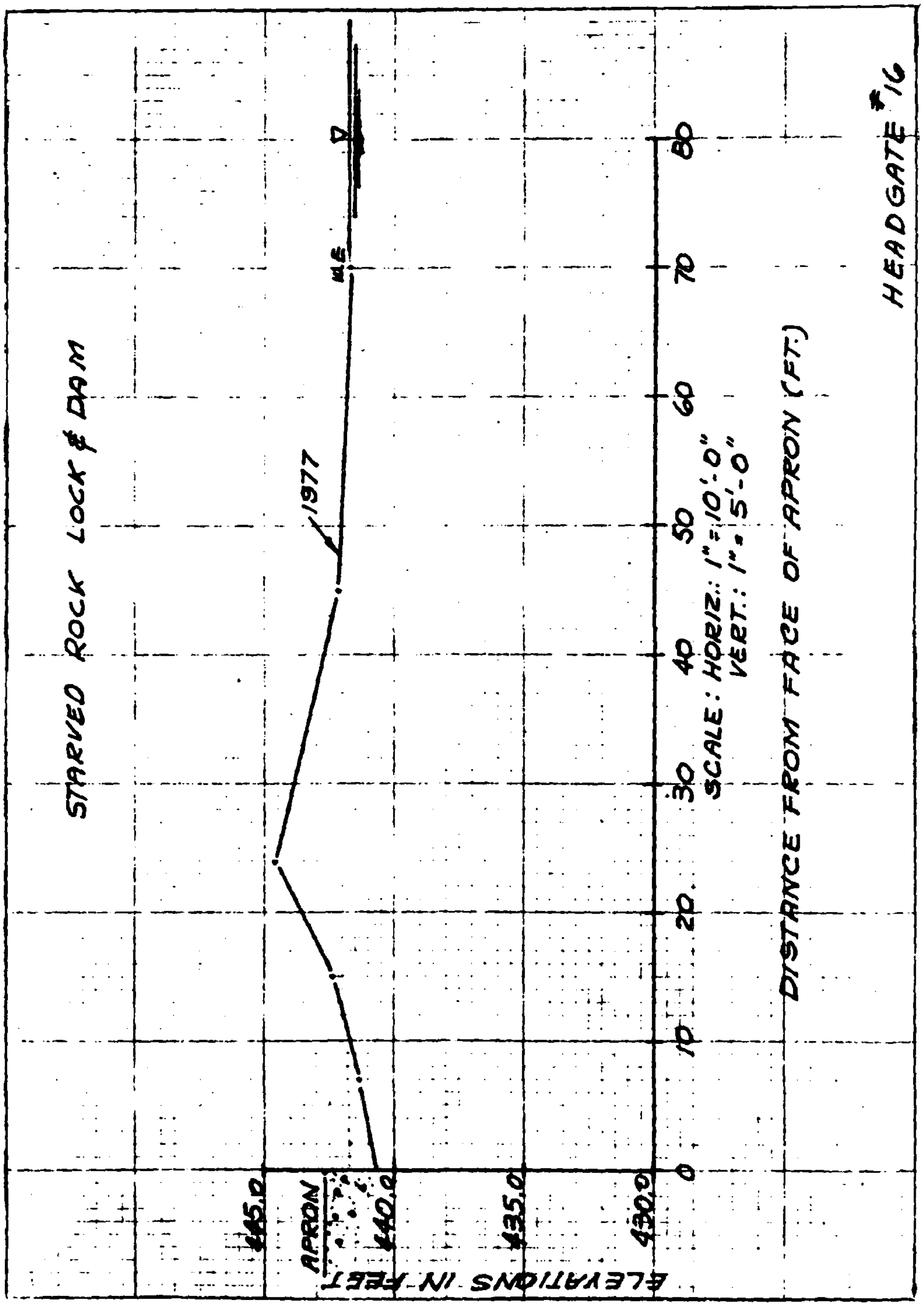
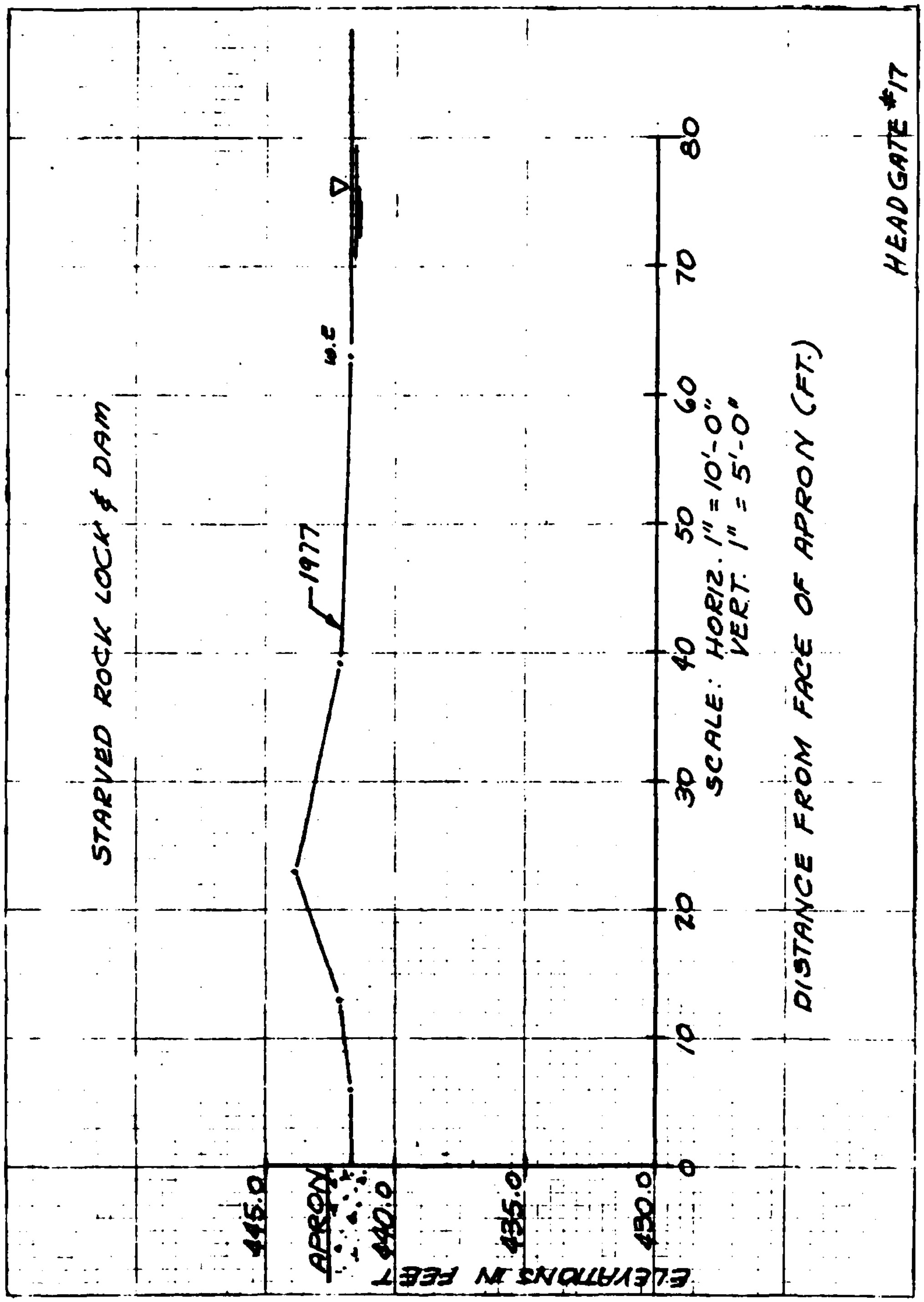

STARVED ROCK LOCK & DAM
1977
W.E.
HEADGATE #16
SCALE: HORIZ: 1" = 10'-0"
VERT.: 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET
APRON
445.0
440.0
435.0
430.0
0
10
20
30
40
50
60
70
80

PLATE A6


STARVED ROCK LOCK & DAM
HEADGATE #17
1977
W.S.
APRON
ELEVATIONS IN FEET
445.0
440.0
435.0
430.0
0
10
20
30
40
50
60
70
80
SCALE: HORIZ. 1" = 10'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)

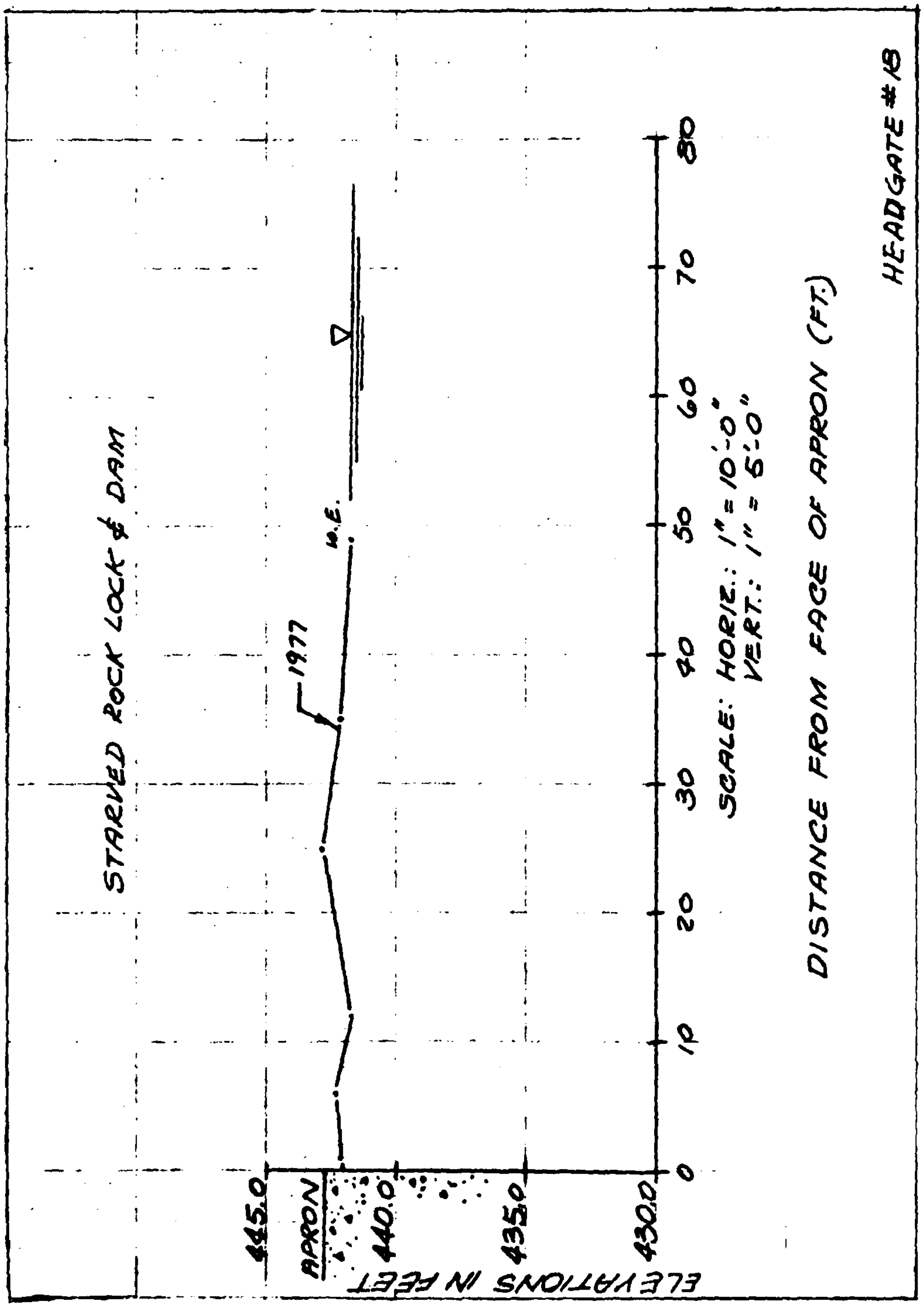
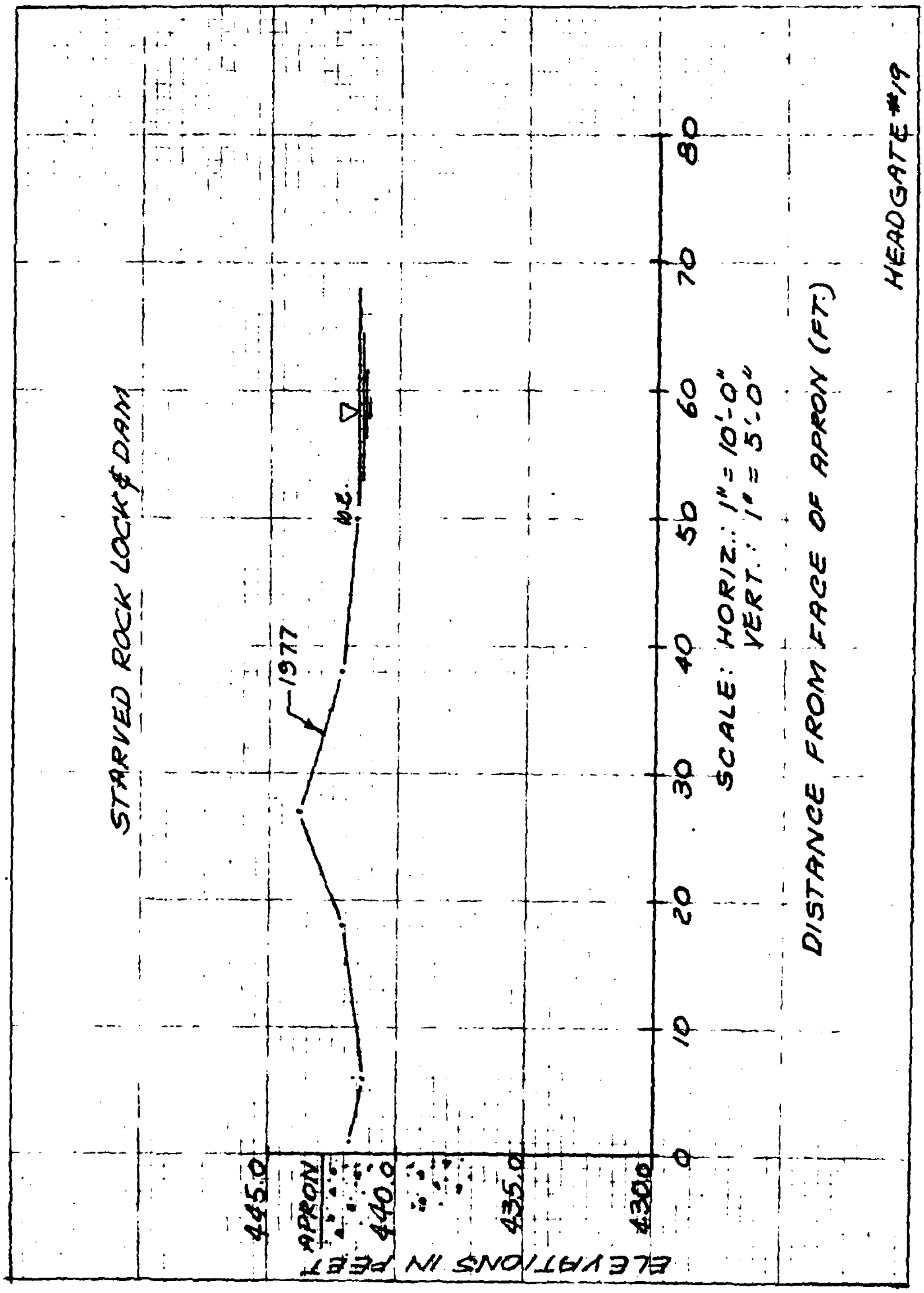

STARVED ROCK LOCK & DAM
HEADGATE #18
1977
W.E.
APRON
445.0
440.0
435.0
430.0
ELEVATIONS IN FEET
0
10
20
30
40
50
60
70
80
SCALE: HORIZ.: 1" = 10'-0"
VERT.: 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)

PLATE A8


STARVED ROCK LOCK & DAM
HEADGATE #19
1977
W.S.
APRON
445.0
440.0
435.0
430.0
ELEVATIONS IN FEET
0
10
20
30
40
50
60
70
80
SCALE: HORIZ.: 1" = 10'-0"
VERT.: 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)

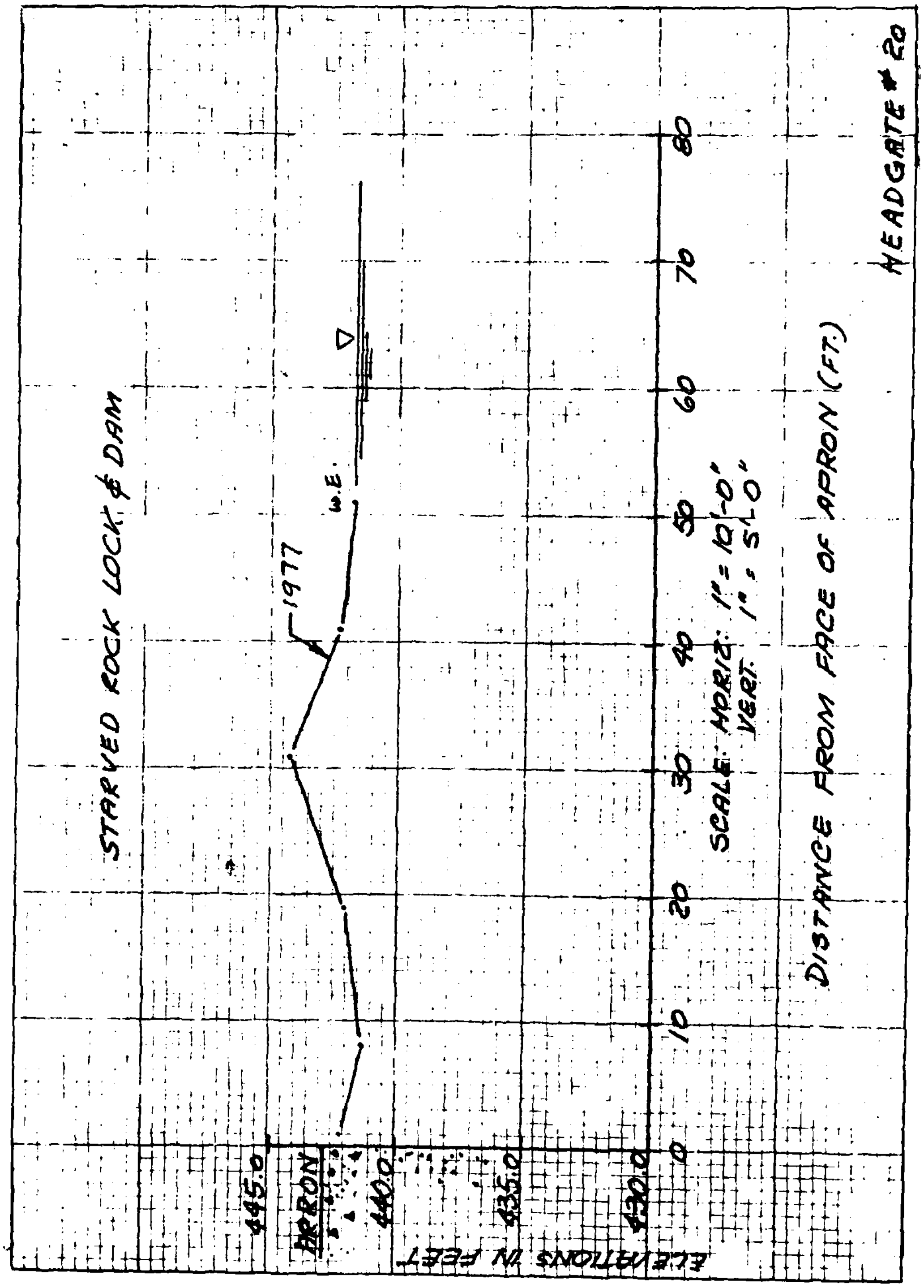
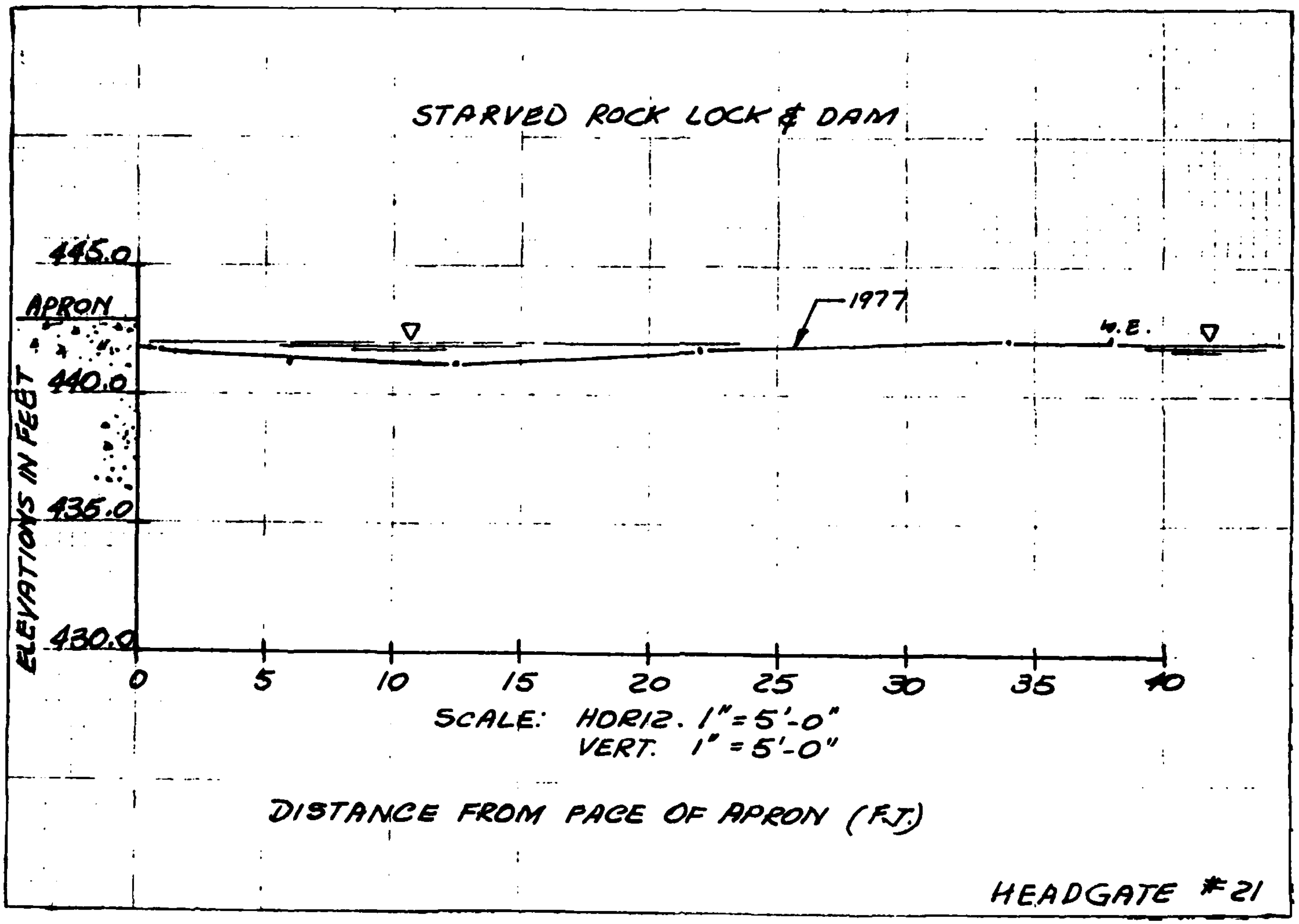

STARVED ROCK LOCK & DAM
HEADGATE # 20
1977
W.E.
SCALE: HORIZ: 1" = 10'-0"
VERT: 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET
APRON
445.0
440.0
435.0
430.0
0
10
20
30
40
50
60
70
80

PLATE A10



STARVED ROCK LOCK & DAM
445.0
APRON
440.0
435.0
430.0
ELEVATIONS IN FEET
1977
W.E.
0
5
10
15
20
25
30
35
40
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM PAGE OF APRON (FT.)
HEADGATE #21

PLATE A11

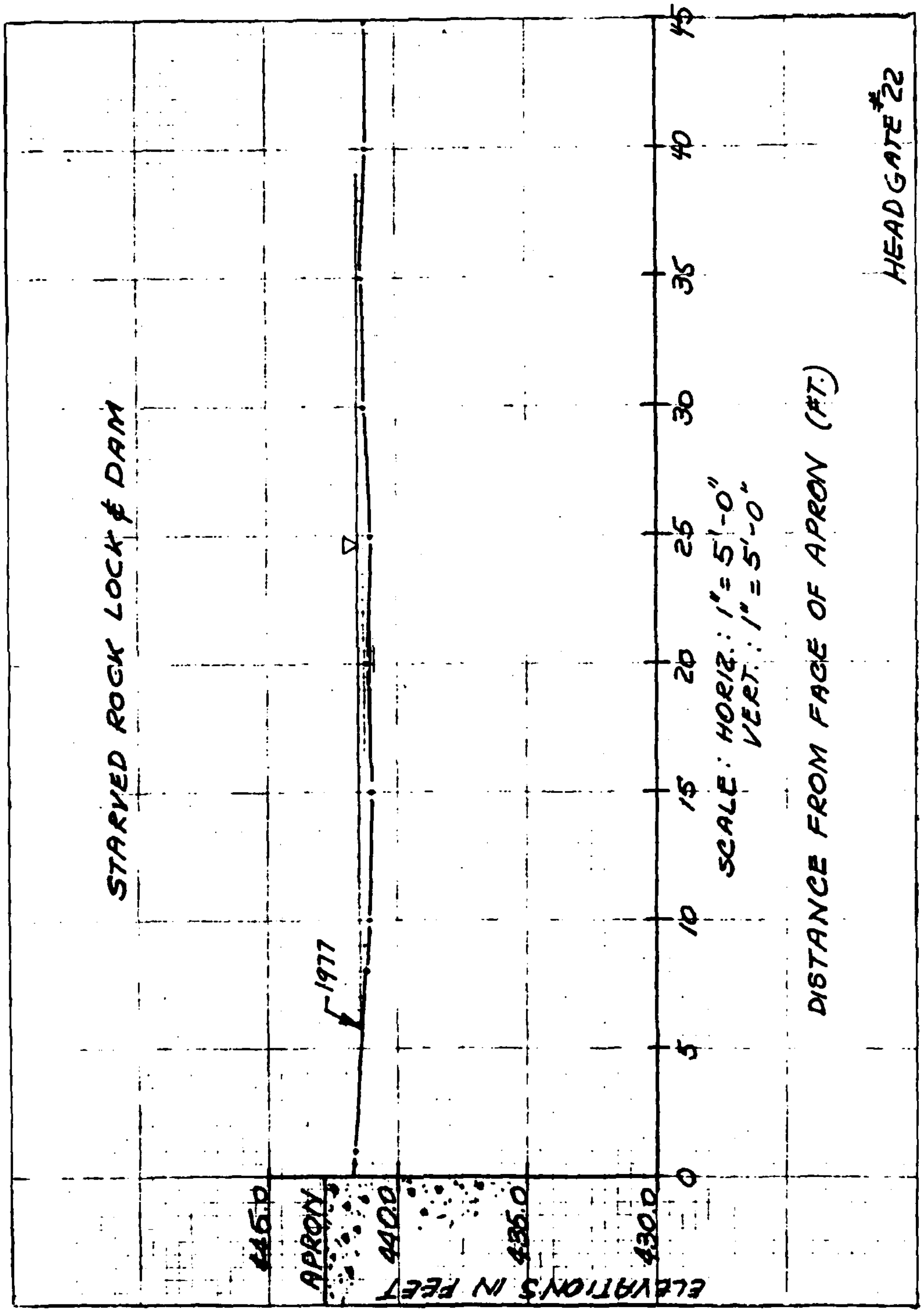

STARVED ROCK LOCK & DAM
HEADGATE #22
1977
SCALE: HORIZ.: 1" = 5'-0"
VERT.: 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
0
5
10
15
20
25
30
35
40
45
ELEVATIONS IN FEET
445.0
440.0
435.0
430.0
APRON

PLATE A12

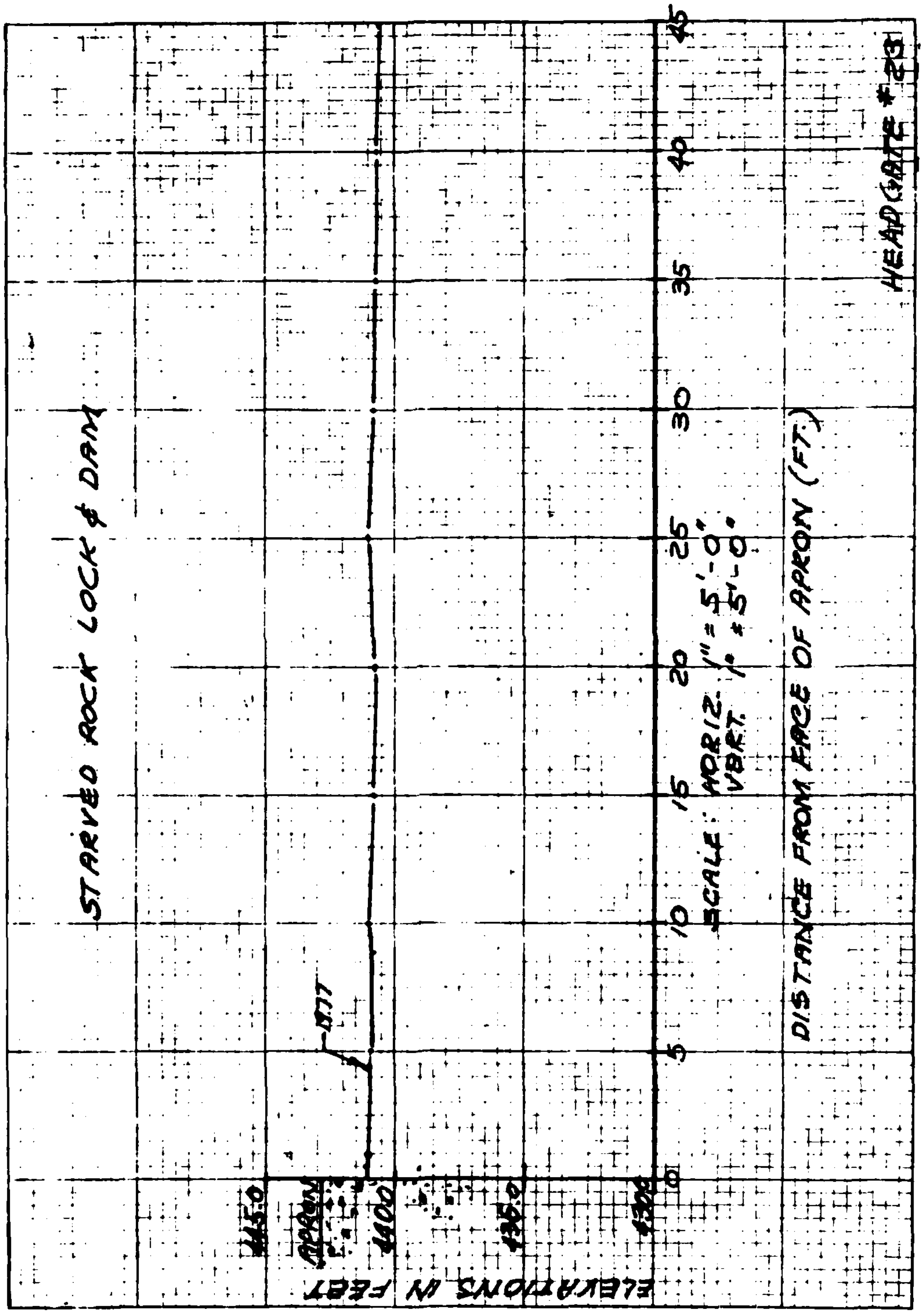

STARVED ROCK LOCK & DAM
HEADGATE #23
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET
445.0
APRON
440.0
435.0
430.0
437.7
0
5
10
15
20
25
30
35
40
45

PLATE A13

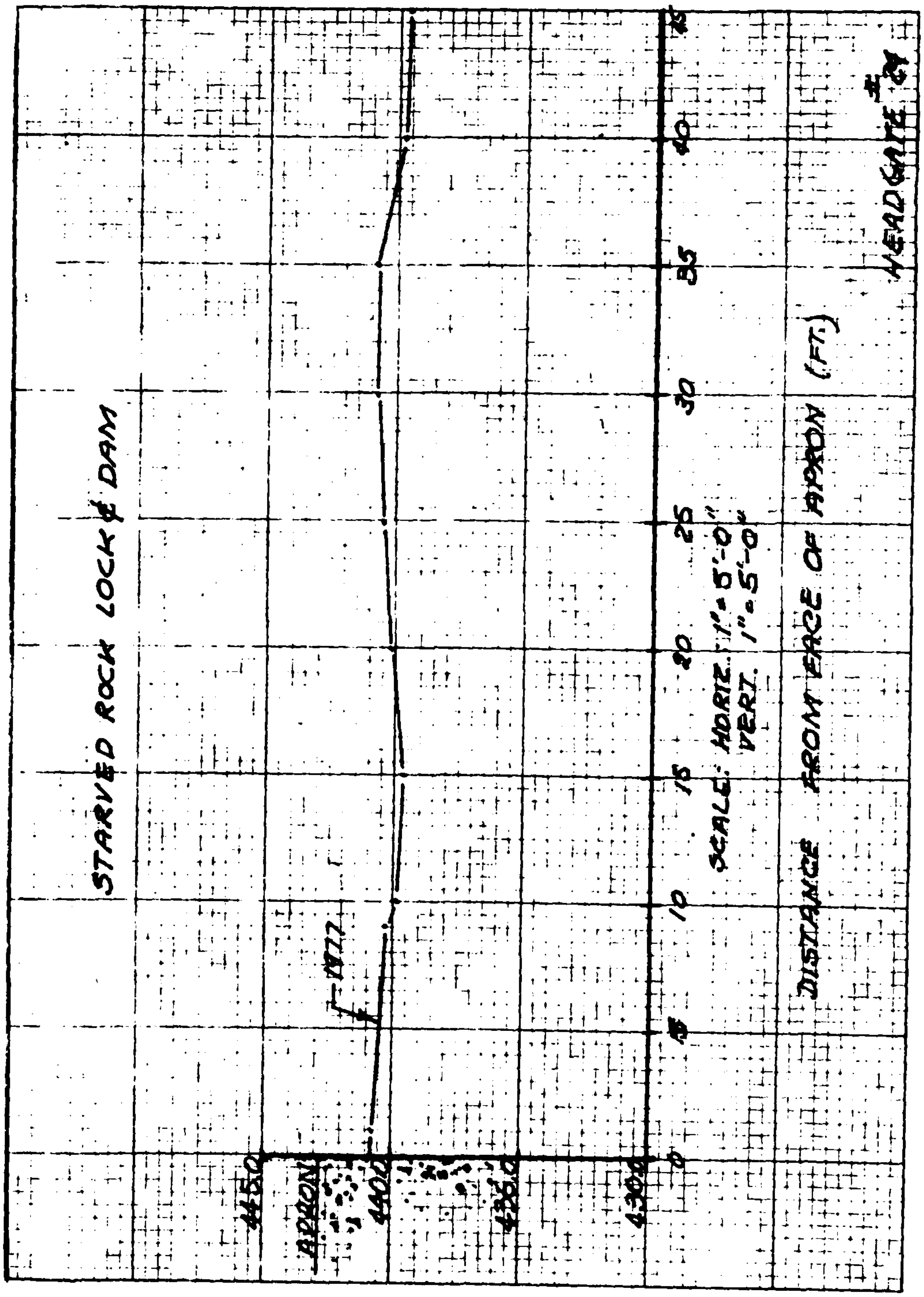

STARVED ROCK LOCK & DAM
HEADGATE
445.0
APRON
440.0
435.0
430.0
1977
0
5
10
15
20
25
30
35
40
45
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)

PLATE A14

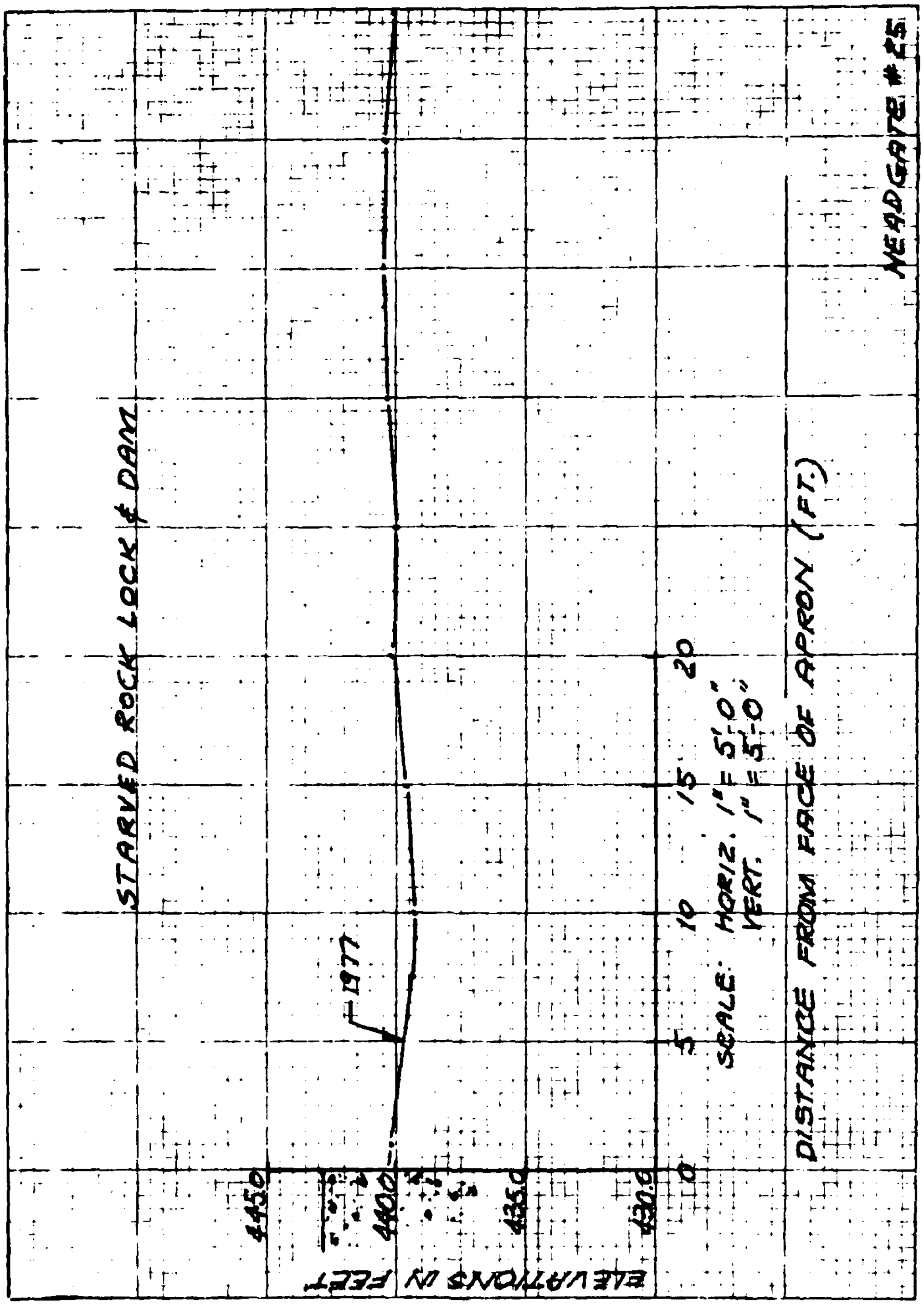

STARVED ROCK LOCK & DAM
HEADGATE # 25
1977
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
0
5
10
15
20
ELEVATIONS IN FEET
445.0
440.0
435.0
430.0

PLATE A15

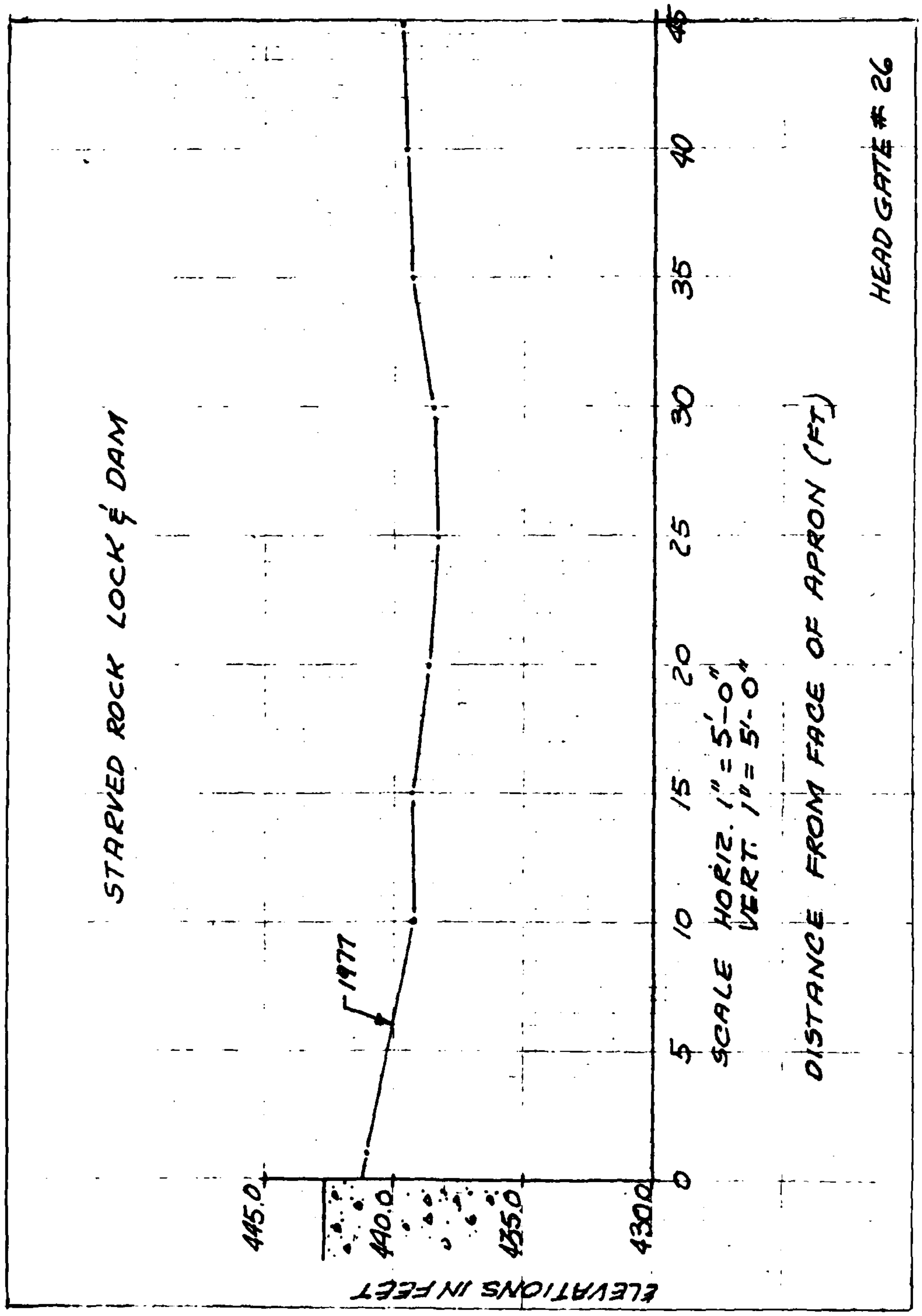

STARVED ROCK LOCK & DAM
HEAD GATE # 26
1977
SCALE HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
0
5
10
15
20
25
30
35
40
45
DISTANCE FROM FACE OF APRON (FT)
445.0
440.0
435.0
430.0
ELEVATIONS IN FEET

PLATE A16

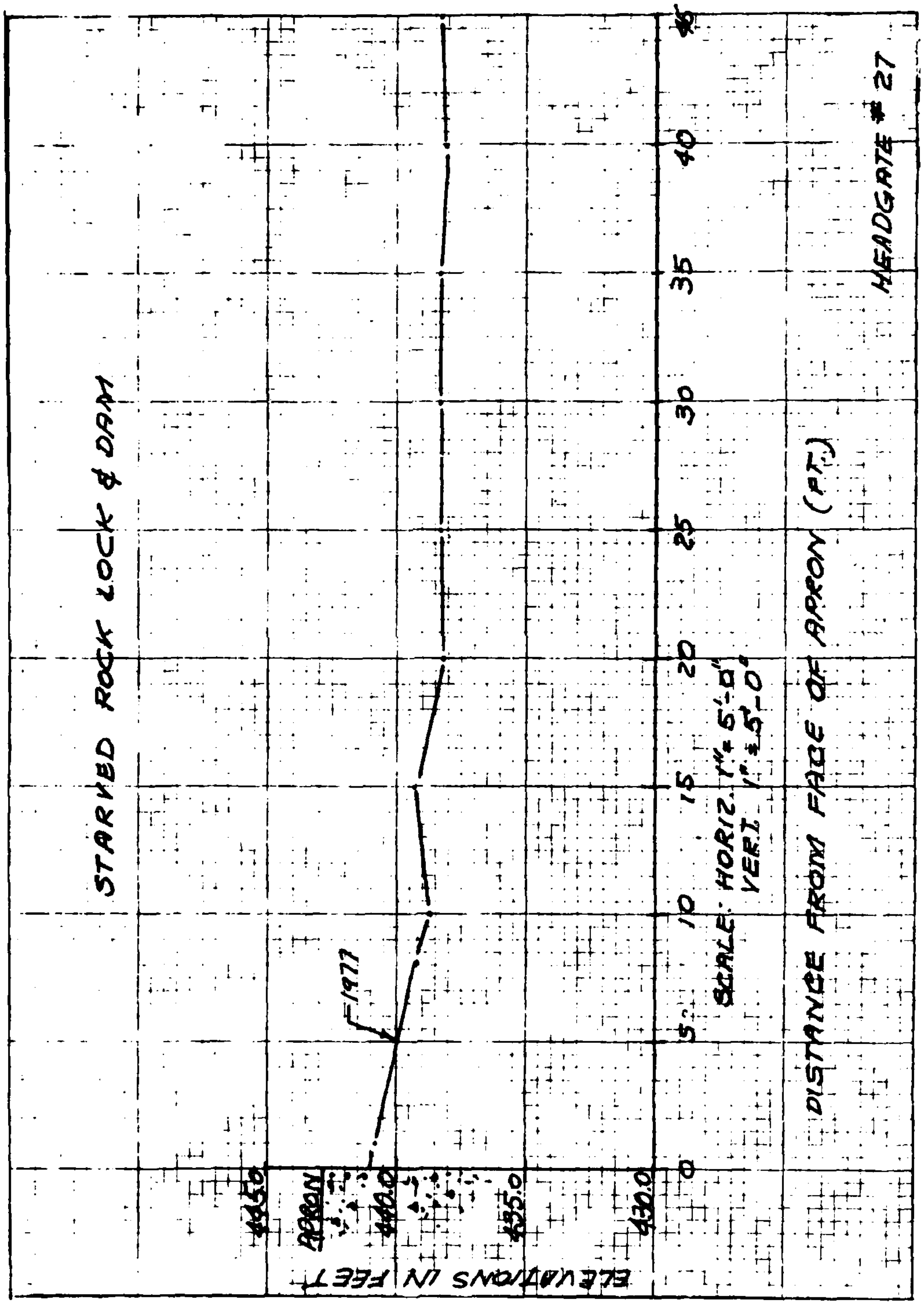

STARVED ROCK LOCK & DAM
HEADGATE # 27
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET
1977
APRON
445.0
440.0
435.0
430.0
0
5
10
15
20
25
30
35
40
45

PLATE A17

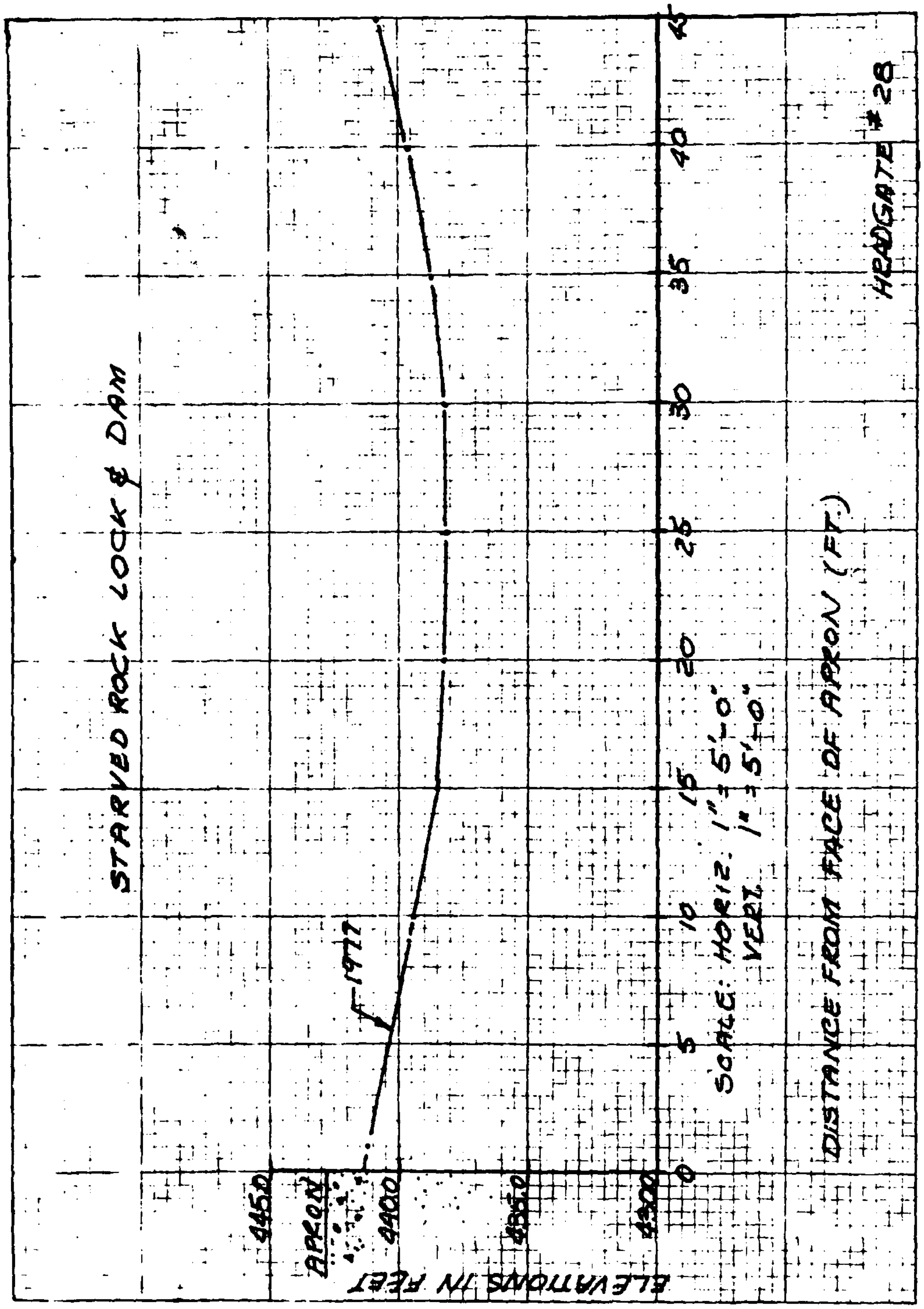

STARVED ROCK LOCK & DAM
HEADGATE #28
1977
APRON
445.0
440.0
435.0
430.0
0
5
10
15
20
25
30
35
40
45
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET

PLATE A18

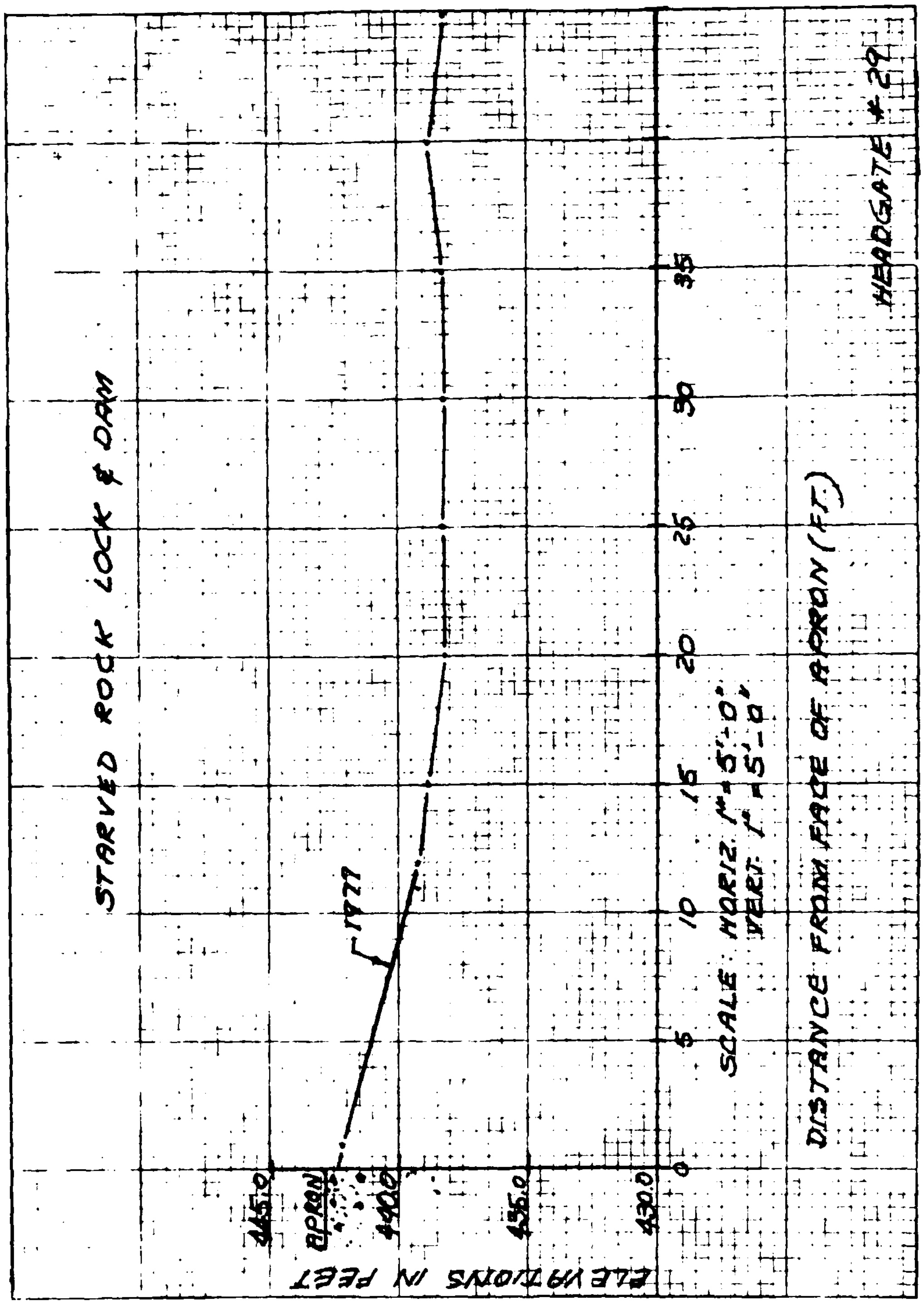

STARVED ROCK LOCK & DAM
HEADGATE # 29
1977
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET
445.0
APRON
440.0
435.0
430.0
0
5
10
15
20
25
30
35

PLATE A19

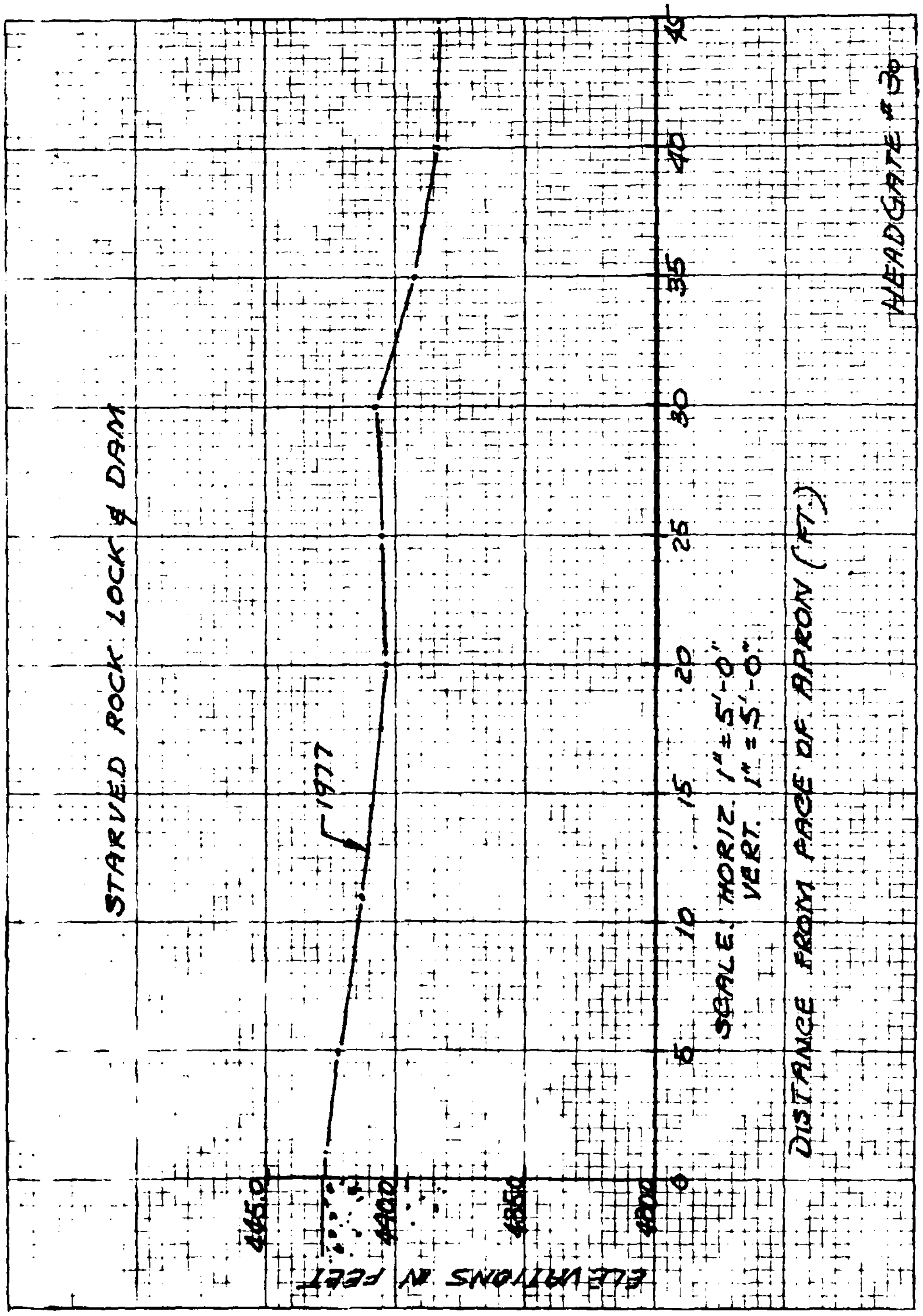
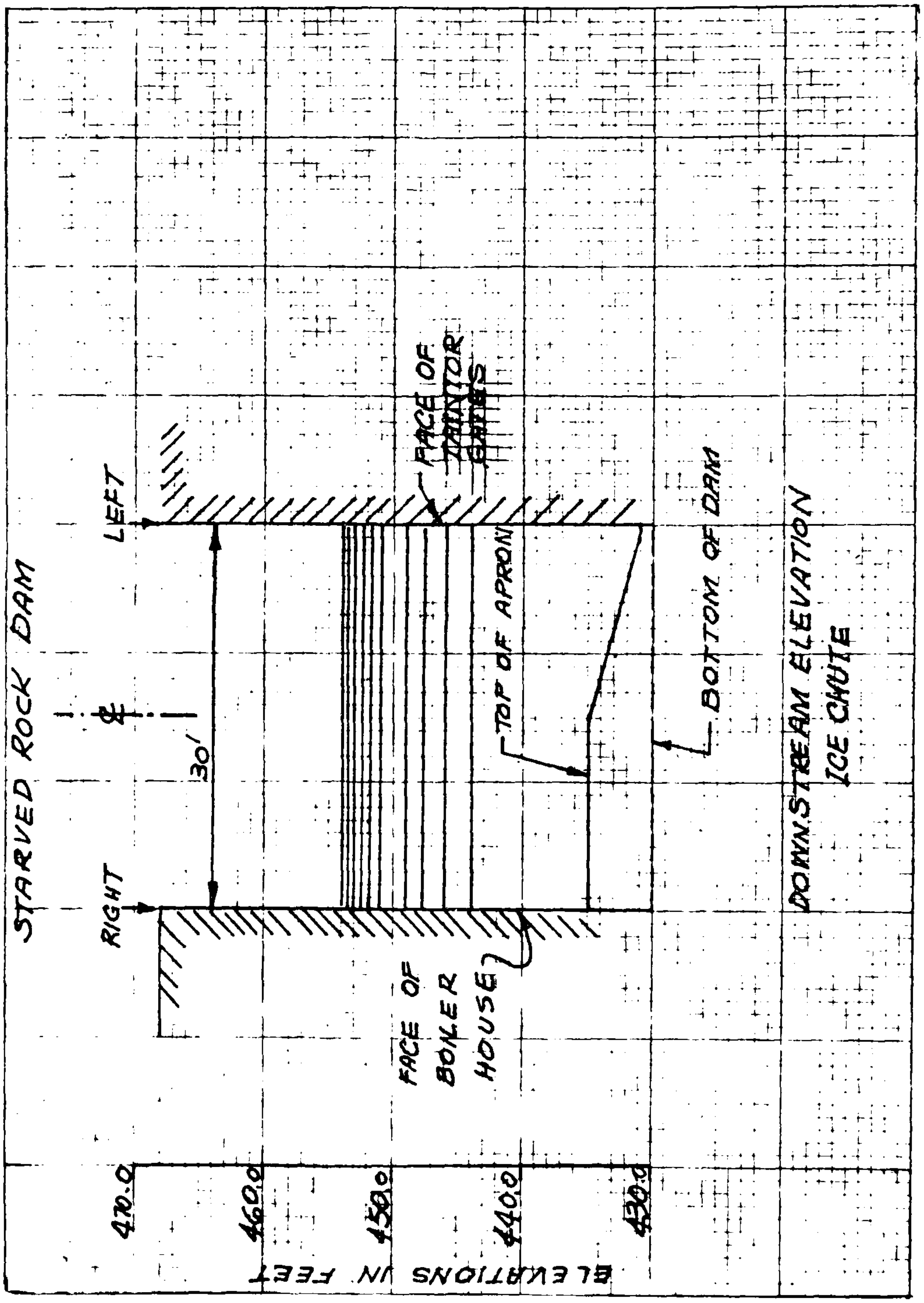
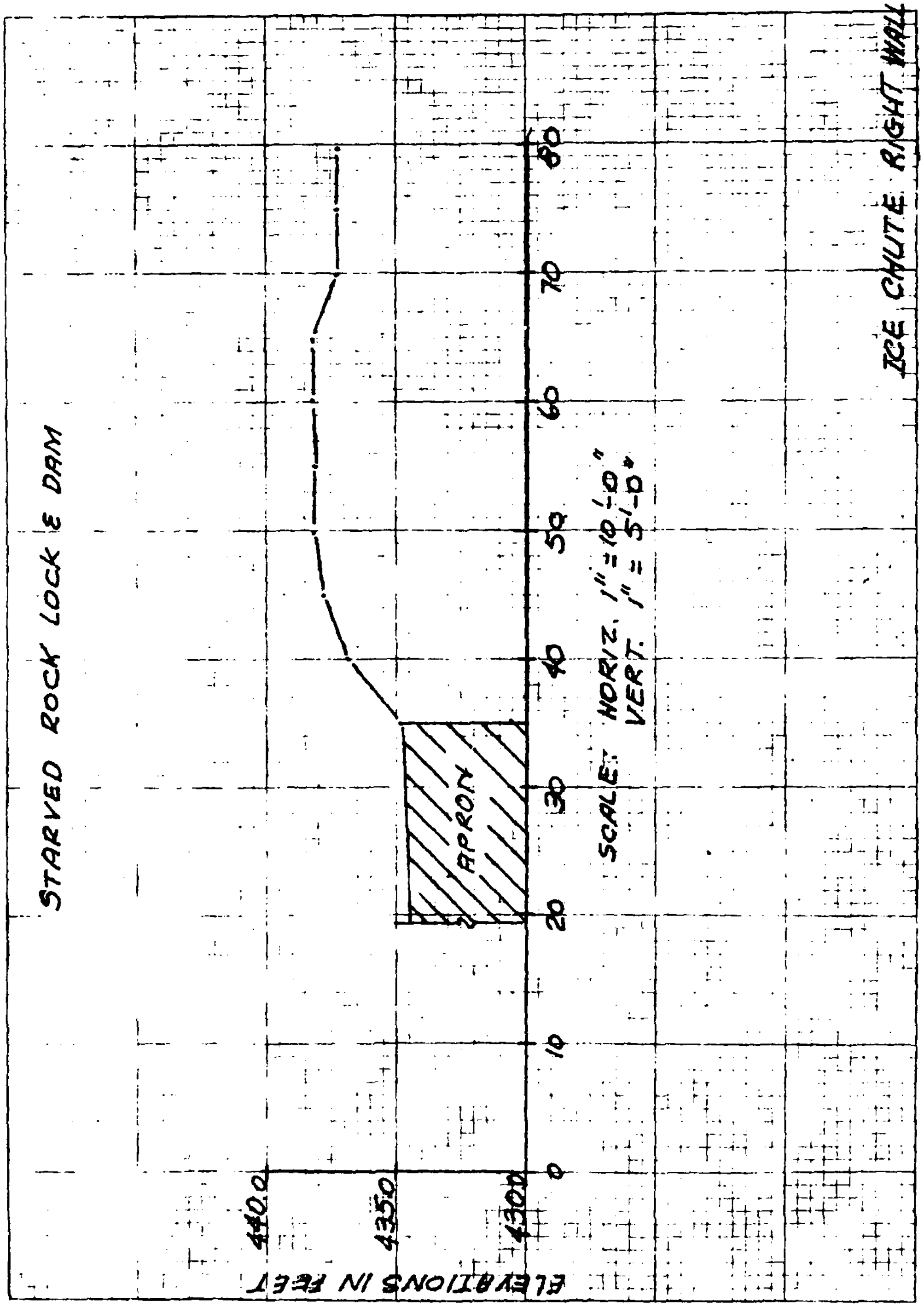

STARVED ROCK LOCK & DAM
HEADGATE # 3
1977
SCALE: HORIZ. 1" = 5'-0"
VERT. 1" = 5'-0"
DISTANCE FROM FACE OF APRON (FT.)
ELEVATIONS IN FEET
445.0
440.0
435.0
430.0
0
5
10
15
20
25
30
35
40
45

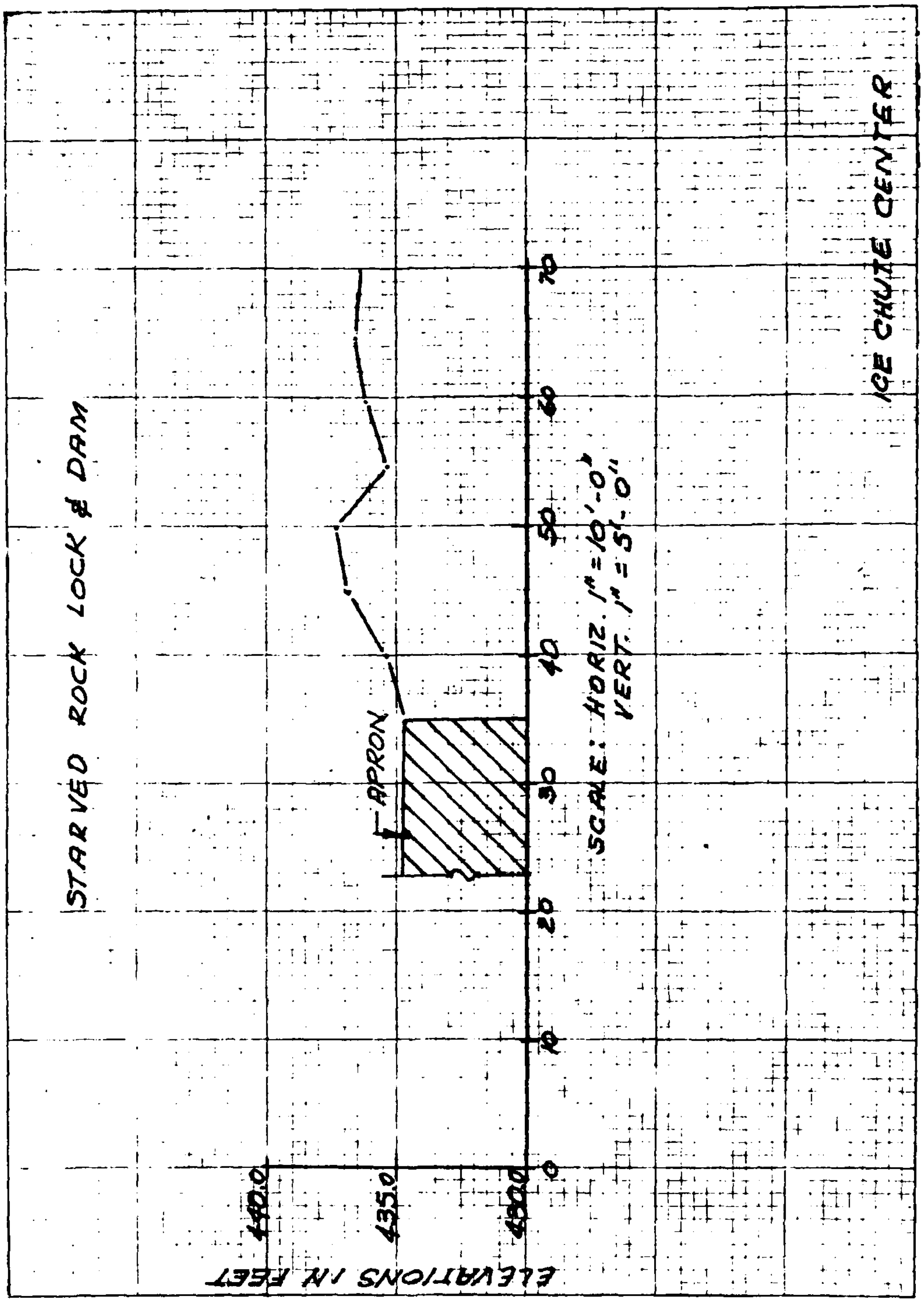
PLATE A20


STARVED ROCK DAM
RIGHT
LEFT
30'
FACE OF TAINTOR GATES
TOP OF APRON
BOTTOM OF DAM
FACE OF BOILER HOUSE
DOWNSTREAM ELEVATION
ICE CHUTE
470.0
460.0
450.0
440.0
430.0
ELEVATIONS IN FEET



STARVED ROCK LOCK & DAM
ICE CHUTE RIGHT WALL
APRON
SCALE: HORIZ. 1" = 10'-0"
VERT. 1" = 5'-0"
ELEVATIONS IN FEET
440.0
435.0
430.0
0
10
20
30
40
50
60
70
80

PLATE A22


STARVED ROCK LOCK & DAM
ICE CHUTE CENTER
APRON
SCALE: HORIZ. 1" = 10'-0"
VERT. 1" = 5'-0"
ELEVATIONS IN FEET
440.0
435.0
430.0
0
10
20
30
40
50
60
70

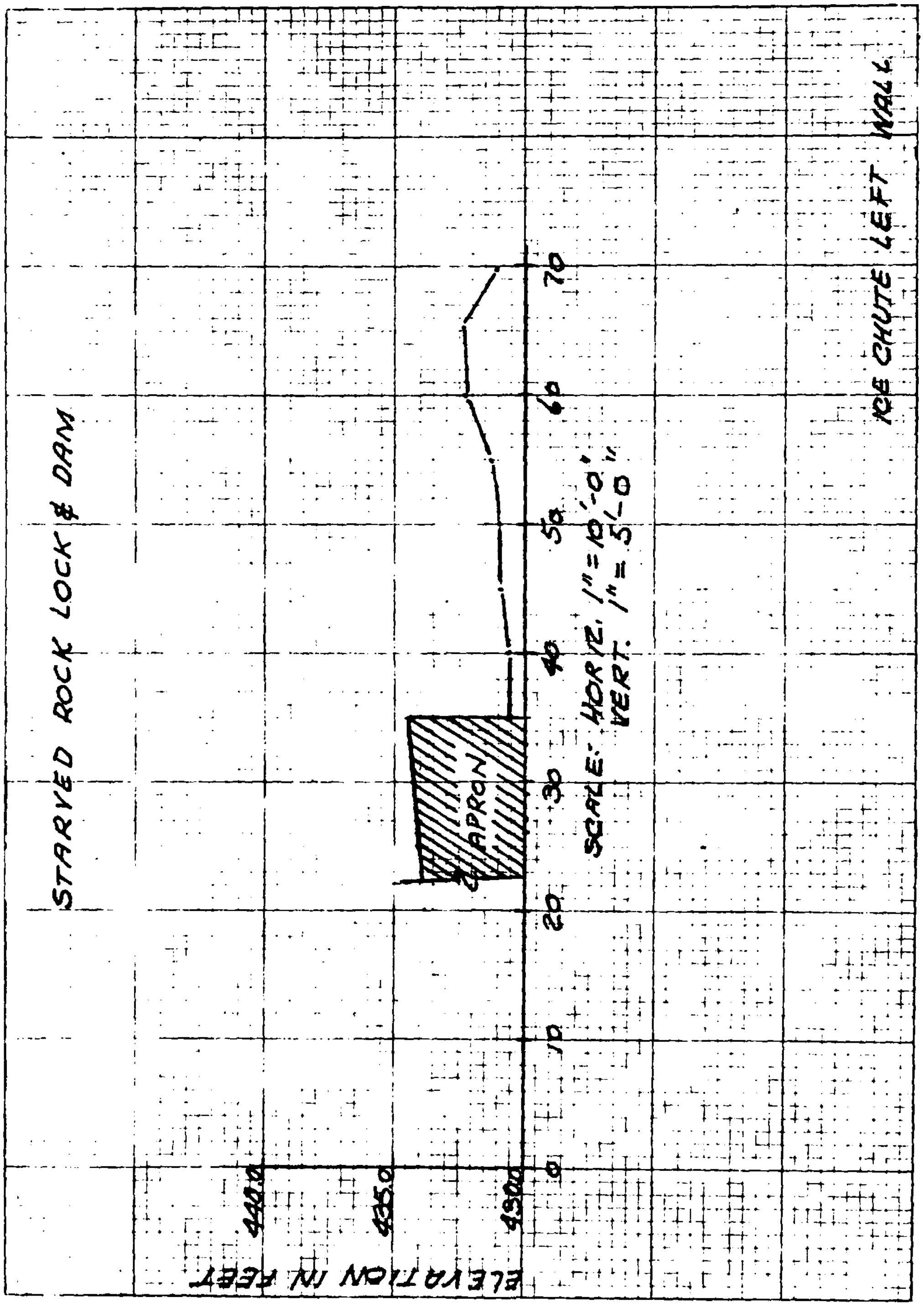
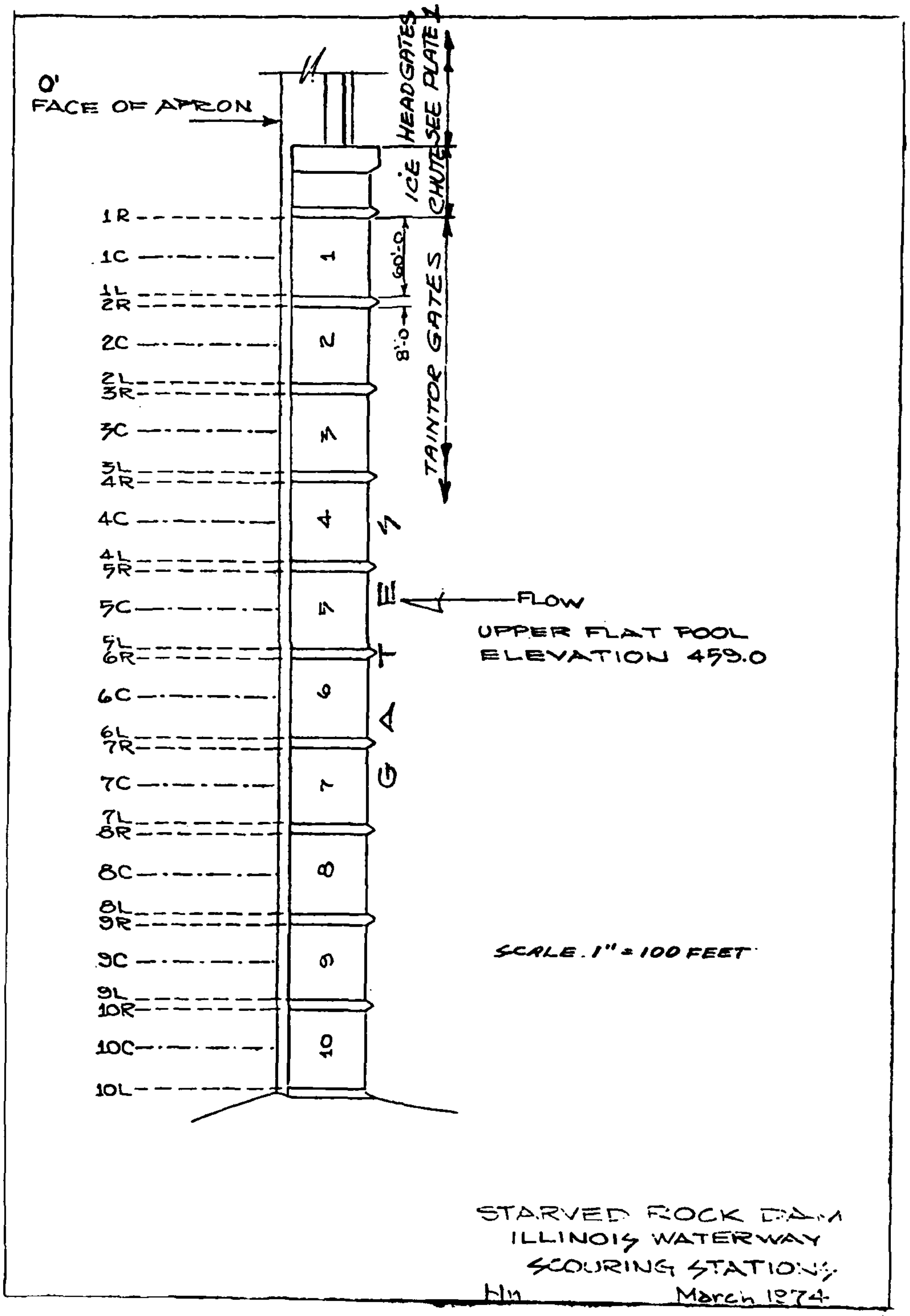

STARVED ROCK LOCK & DAM
ICE CHUTE LEFT WALL
SCALE: HORIZ. 1" = 10'-0"
VERT. 1" = 5'-0"
APRON
ELEVATION IN FEET
440.0
435.0
430.0
0
10
20
30
40
50
60
70

PLATE A24



0'
FACE OF APRON
HEADGATES SEE PLATE
ICE CHUTE
TAINTOR GATES
60'-0
8'-0
1R
1C
1L
2R
2C
2L
3R
3C
3L
4R
4C
4L
5R
5C
5L
6R
6C
6L
7R
7C
7L
8R
8C
8L
9R
9C
9L
10R
10C
10L
1
2
3
4
5
6
7
8
9
10
GATES
FLOW
UPPER FLAT POOL
ELEVATION 459.0
SCALE. 1" = 100 FEET
STARVED ROCK DAM
ILLINOIS WATERWAY
SCOURING STATIONS
March 1974

PLATE A25

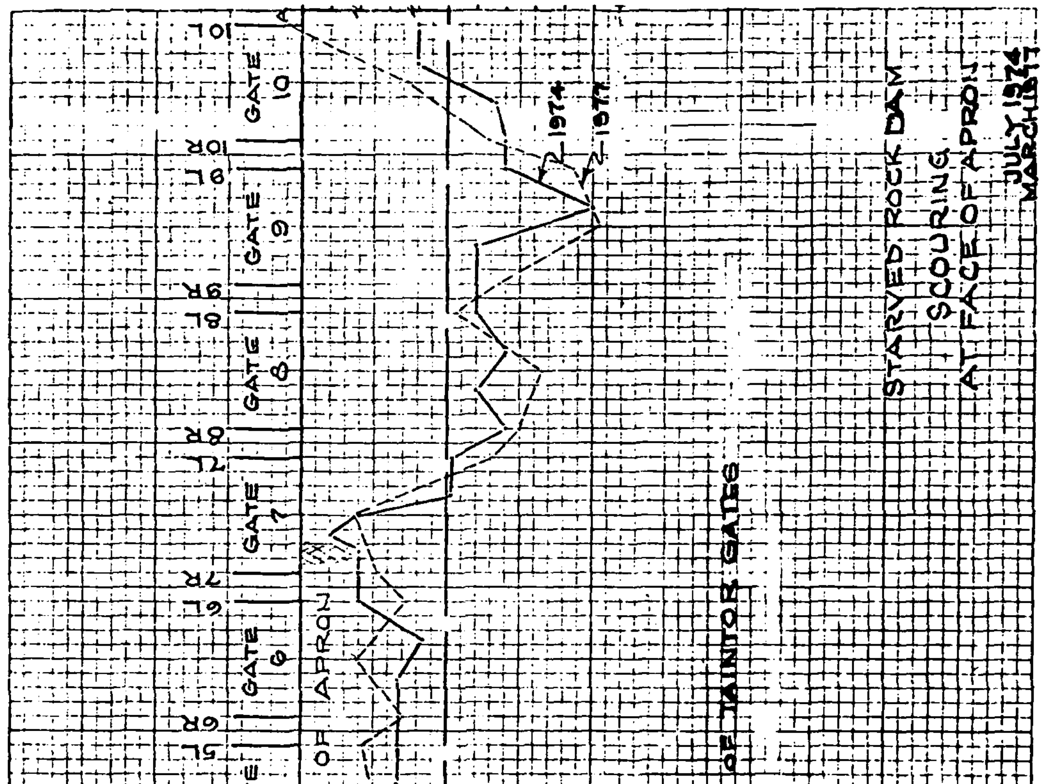

STARVED ROCK DAM
SCOURING
AT FACE OF APRON
JULY 1974
MARCH 1977
DOWNSTREAM ELEVATION OF TAINTOR GATES
FACE OF APRON
GATE 1
GATE 2
GATE 3
GATE 4
GATE 5
GATE 6
GATE 7
GATE 8
GATE 9
GATE 10
1R
1L
2R
2L
3R
3L
4R
4L
5R
5L
6R
6L
7R
7L
8R
8L
9R
9L
10R
10L
1974
1977
430.18
425.6
420.6
SECTION

PLATE A26

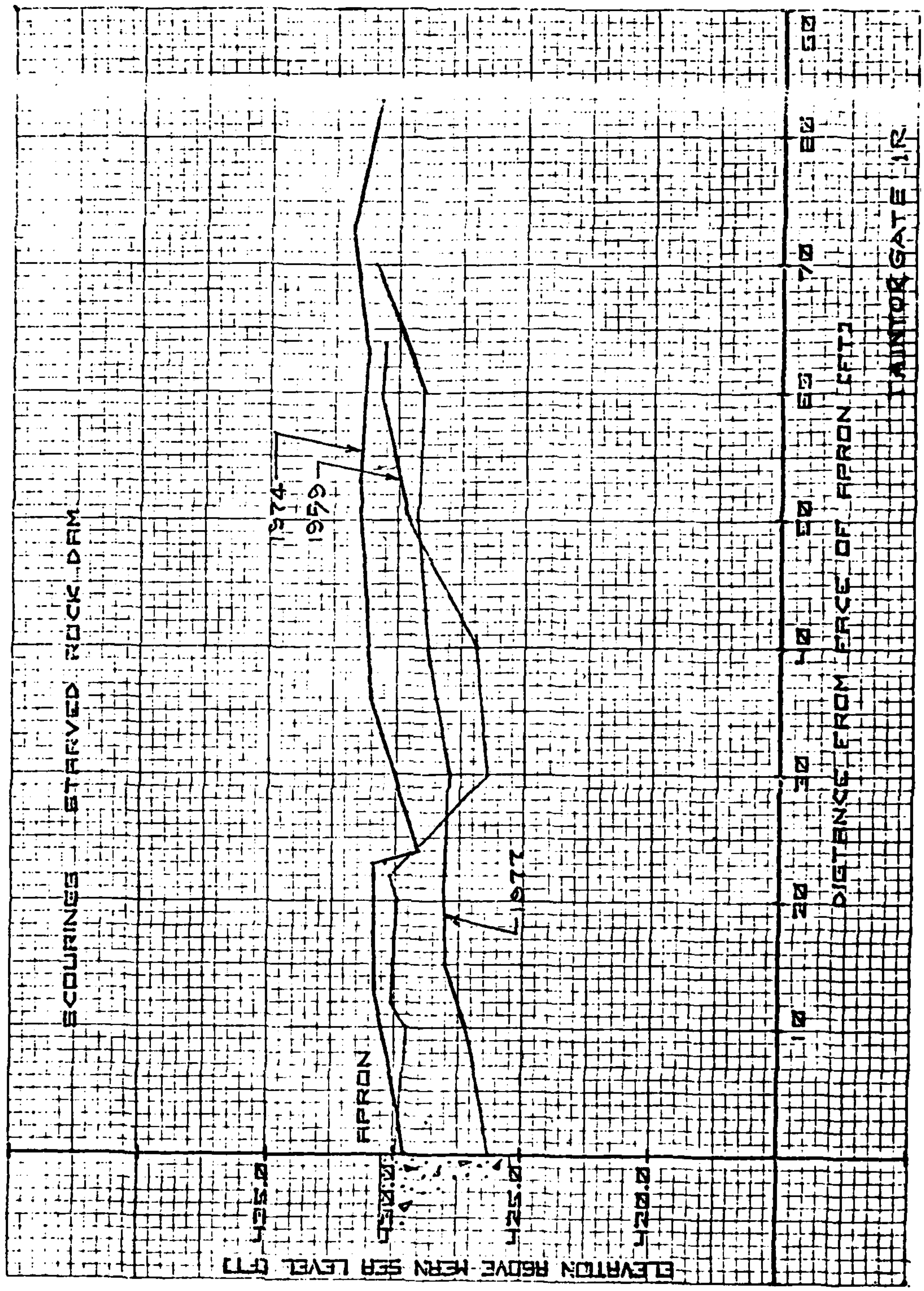

SCOURINGS STARVED ROCK DAM
TAINTOR GATE 1R
1974
1959
1977
APRON
10
20
30
40
50
60
70
80
90
DISTANCE FROM FACE OF APRON (FT)
435.0
425.0
420.0
ELEVATION ABOVE MEAN SEA LEVEL (FT)

PLATE A27

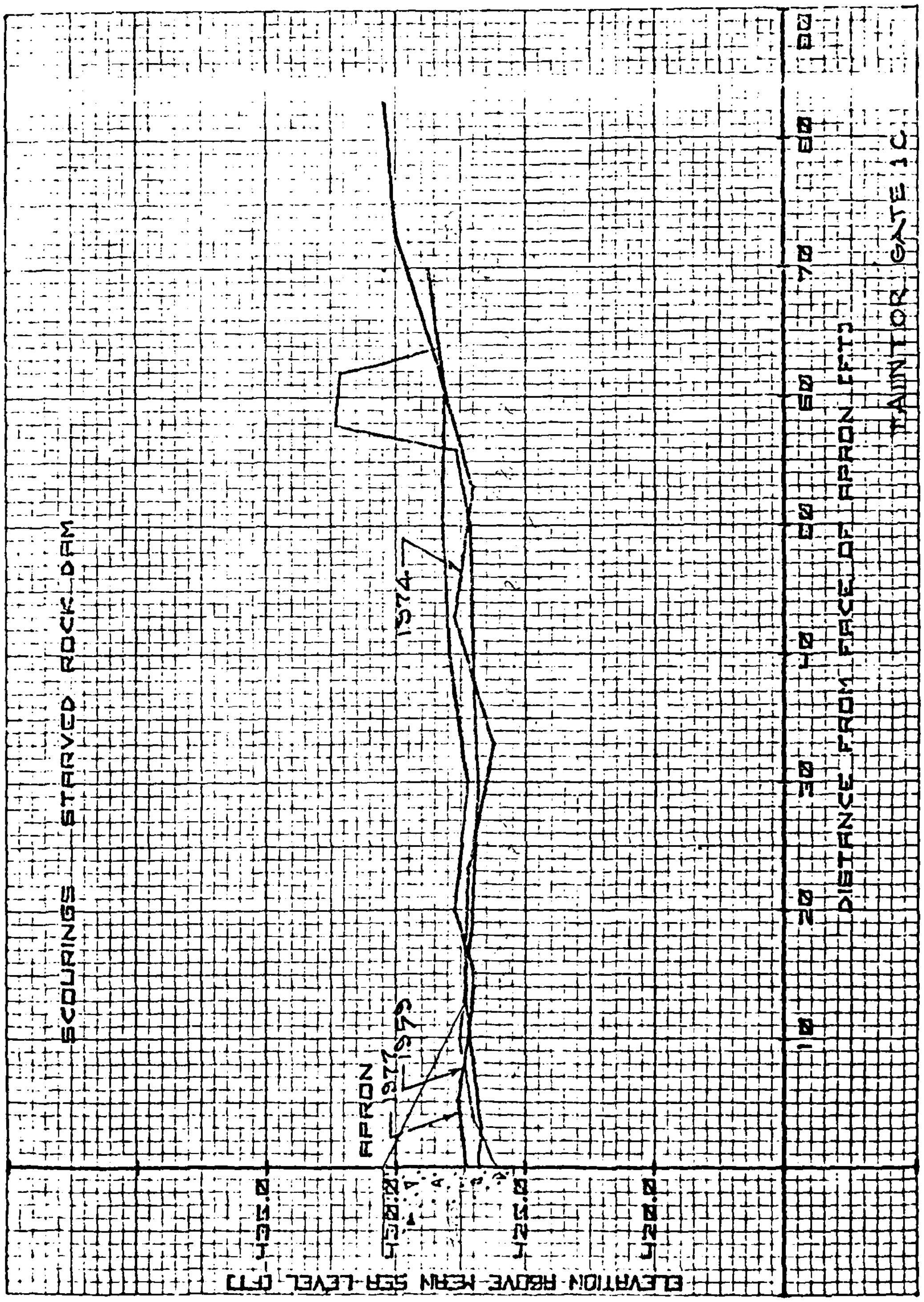

SCOURINGS STARVED ROCK DAM
TAINTOR GATE 1C
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
10
20
30
40
50
60
70
80
90
435.0
430.0
425.0
420.0
APRON
1974
1977
1979

PLATE A28

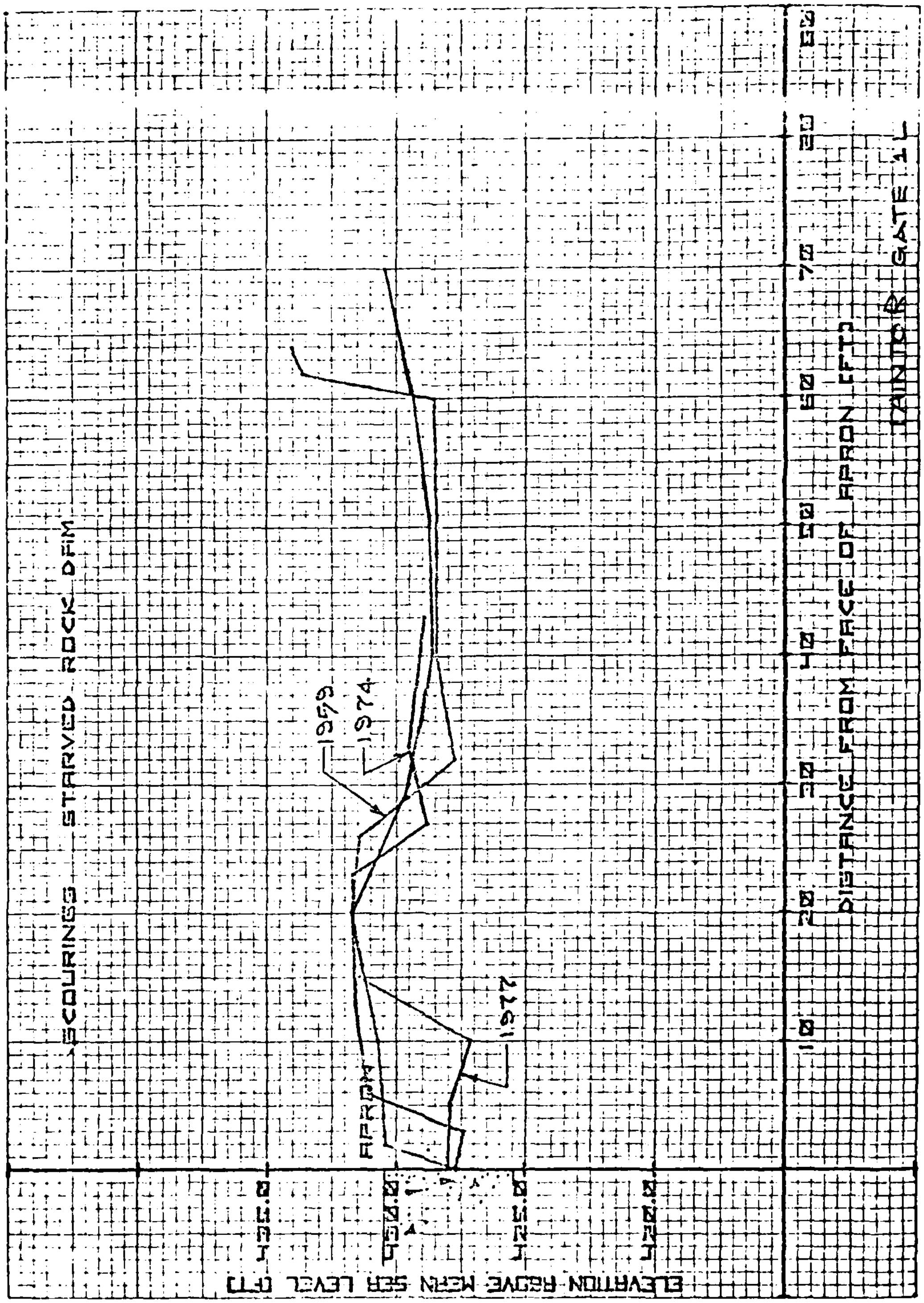

SCOURINGS STARVED ROCK DAM
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 1L
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1979
1974
1977
APRON
10
20
30
40
50
60
70
80
90

PLATE A29

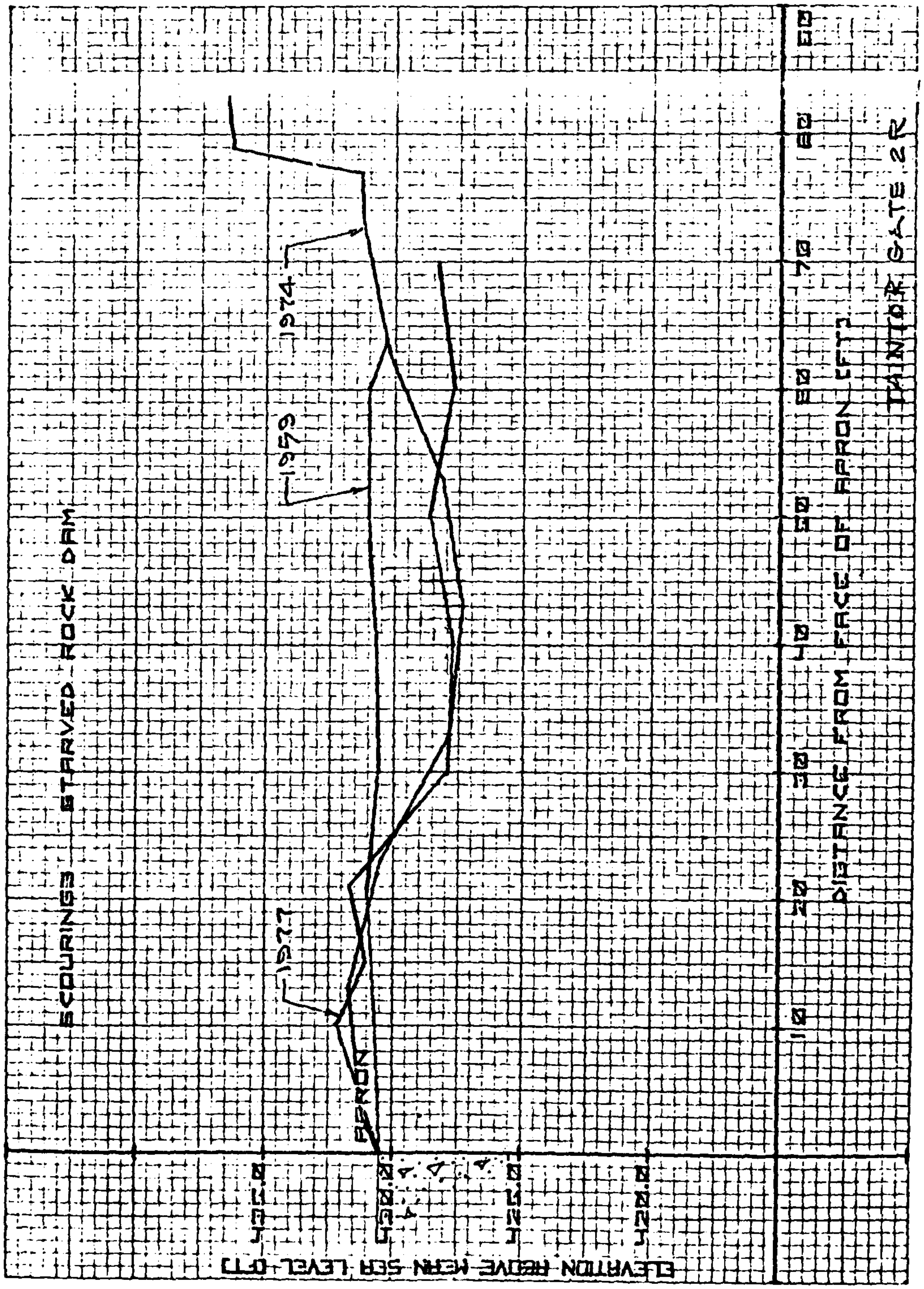

SCOURINGS STARVED ROCK DAM
TAINTOR GATE 2R
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1974
1979
1977
APRON
10
20
30
40
50
60
70
80
90
430.0
425.0
420.0

PLATE A30

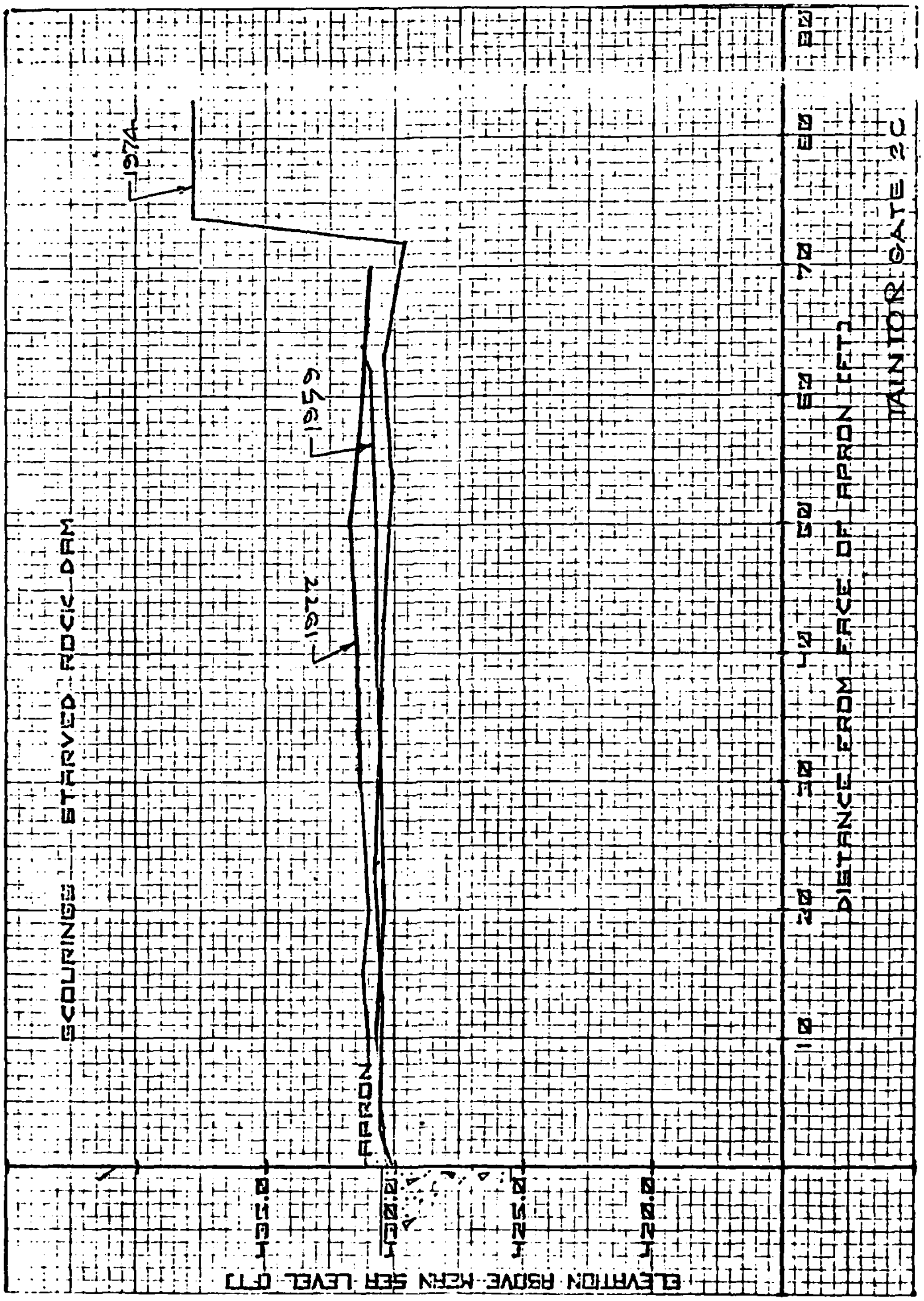

SCOURINGS STARVED ROCK DAM
1974
1959
1977
APRON
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 2C
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90

PLATE A31

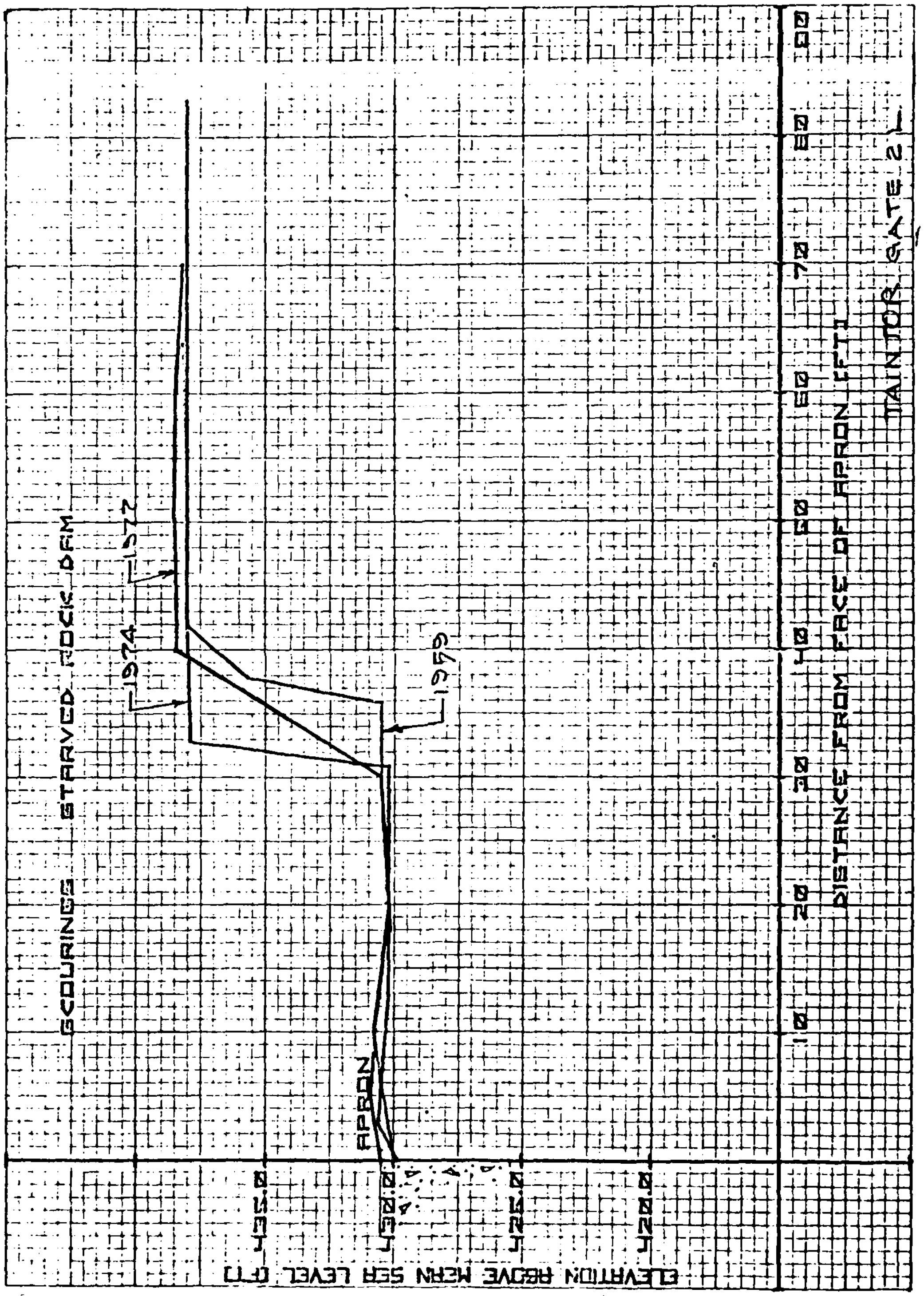

SCOURINGS STARVED ROCK DAM
TAINTOR GATE 2
1974
1977
1979
APRON
DISTANCE FROM FACE OF APRON (FT)
10
20
30
40
50
60
70
80
100
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0

PLATE A32

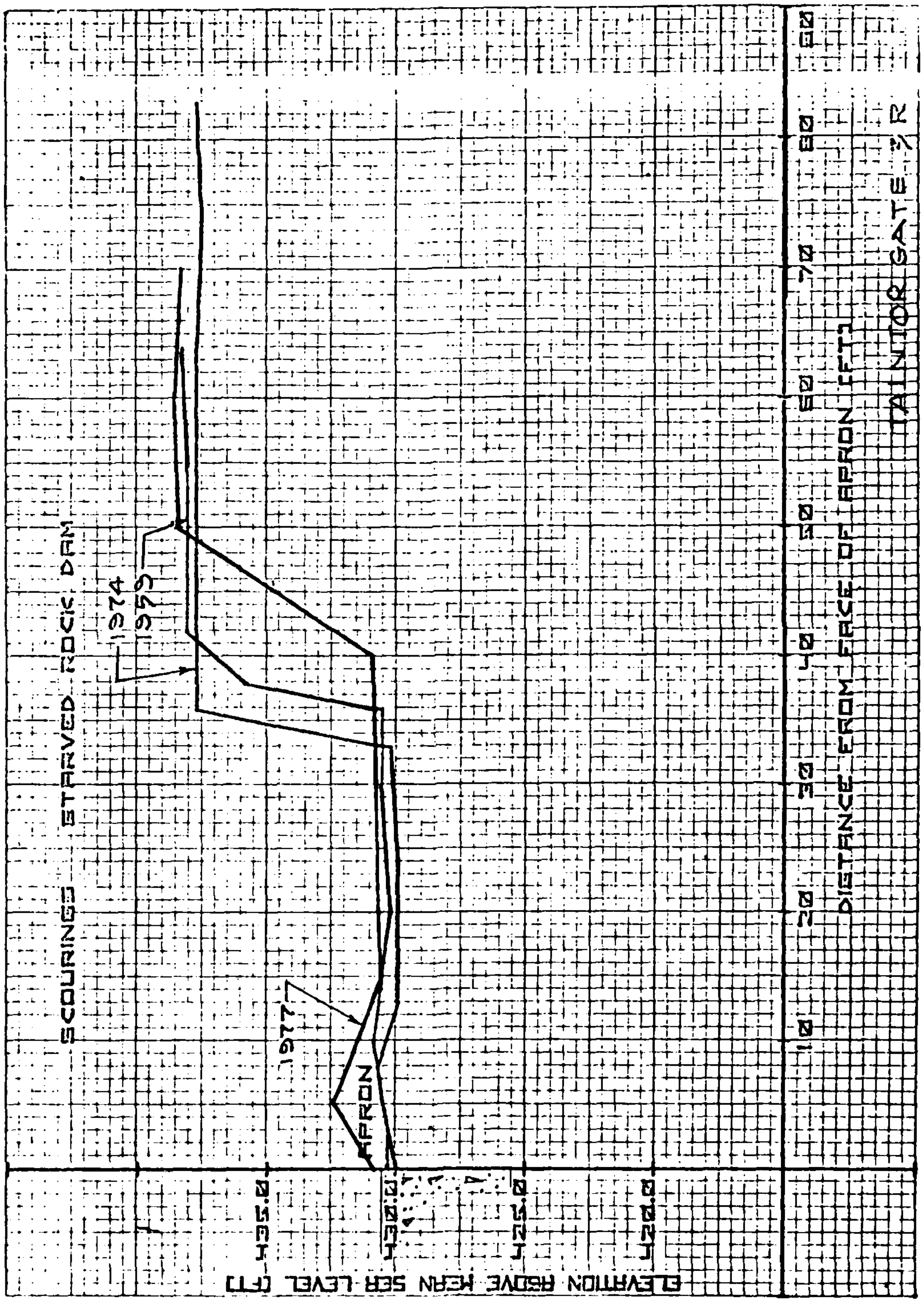

SCOURINGS STARVED ROCK DAM
1974
1977
APRON
DISTANCE FROM FACE OF APRON (FT)
10
20
30
40
50
60
70
80
TAINTOR GATE 7R
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0

PLATE A33

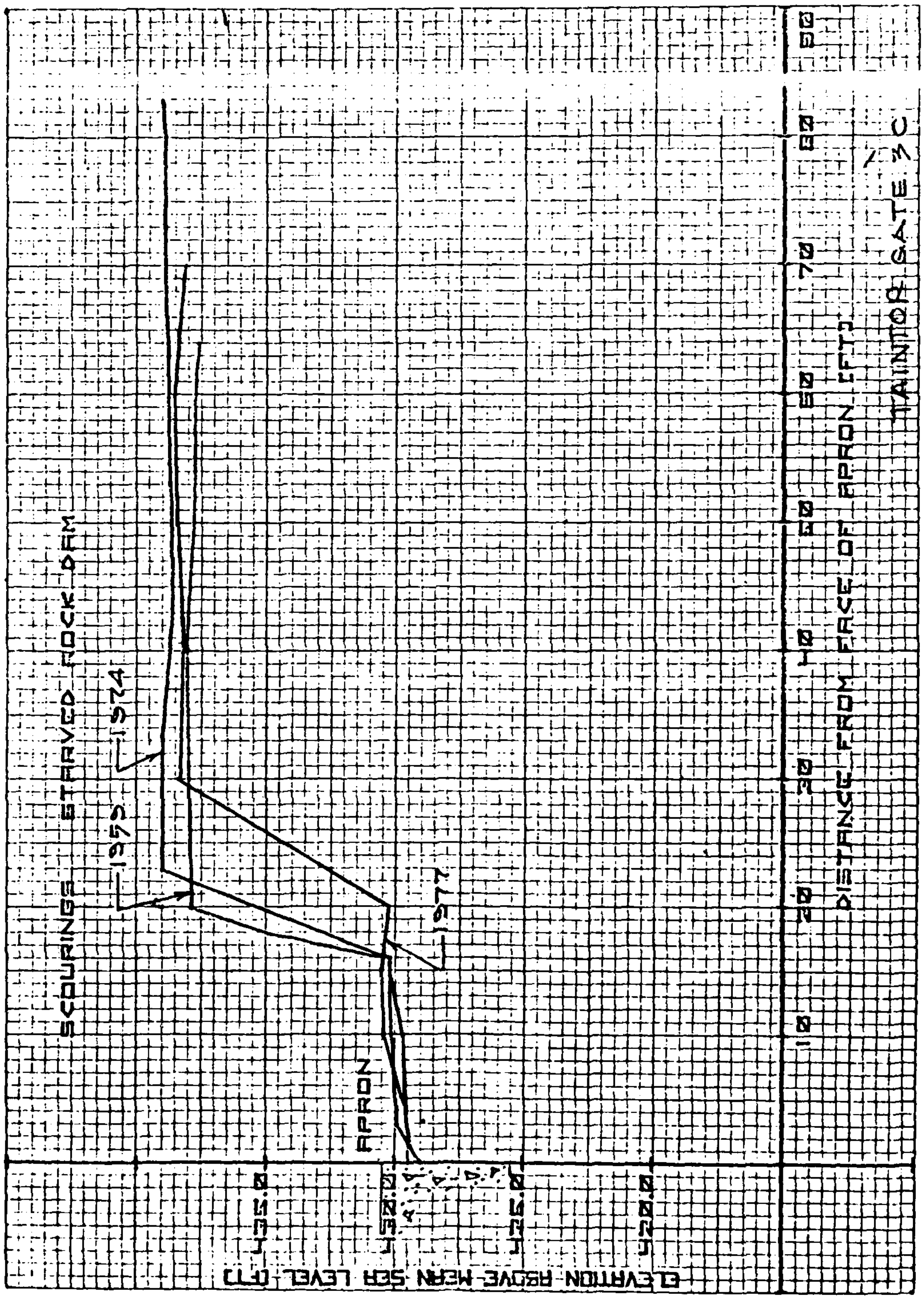
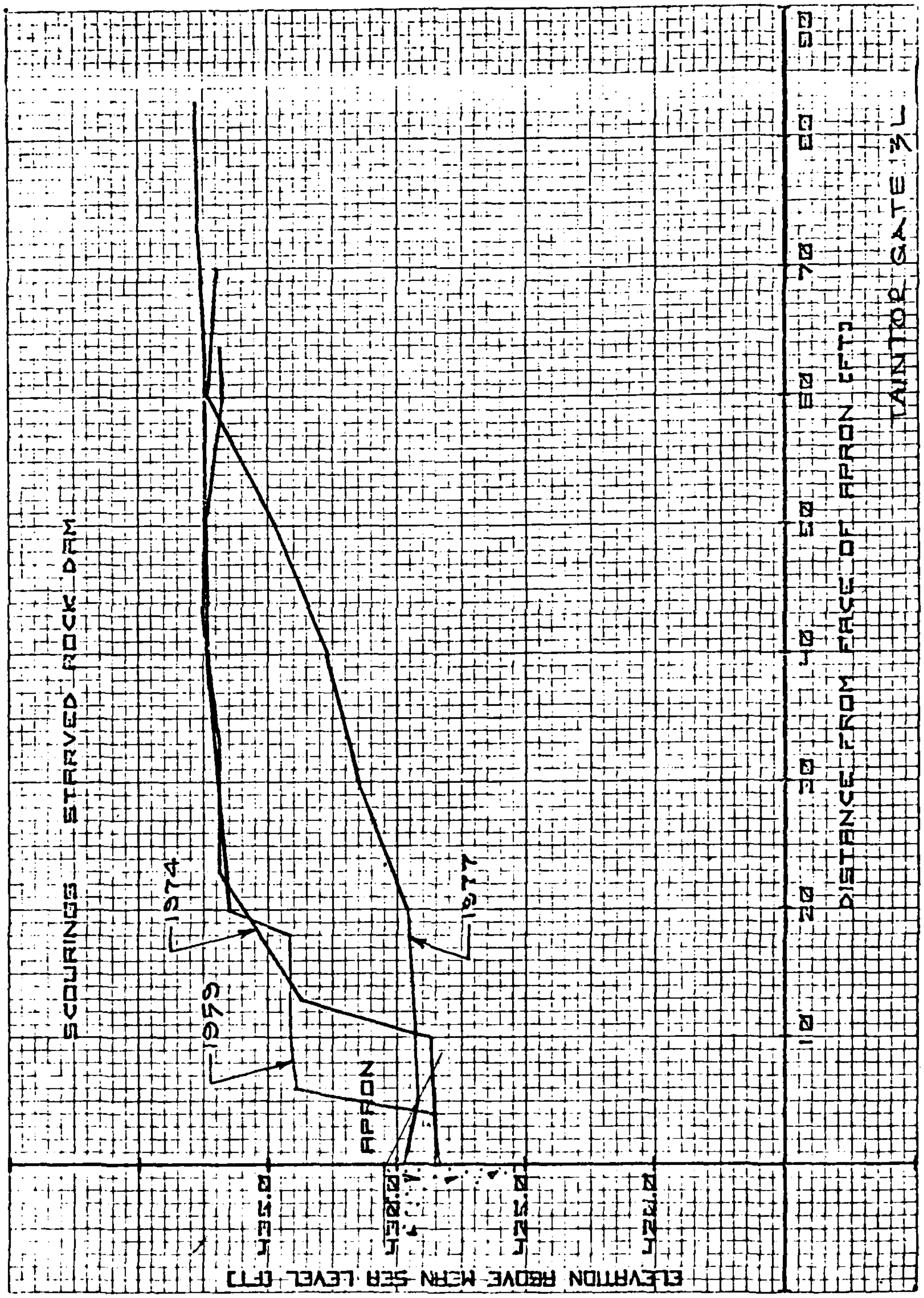

SCOURINGS STARVED ROCK DAM
1975
1974
1977
APRON
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 3C
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90

PLATE A34



SCOURINGS STARVED ROCK DAM
TAINTOR GATE 3L
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1974
1979
1977
APRON
10
20
30
40
50
60
70
80
90
435.0
430.0
425.0
420.0

PLATE A35

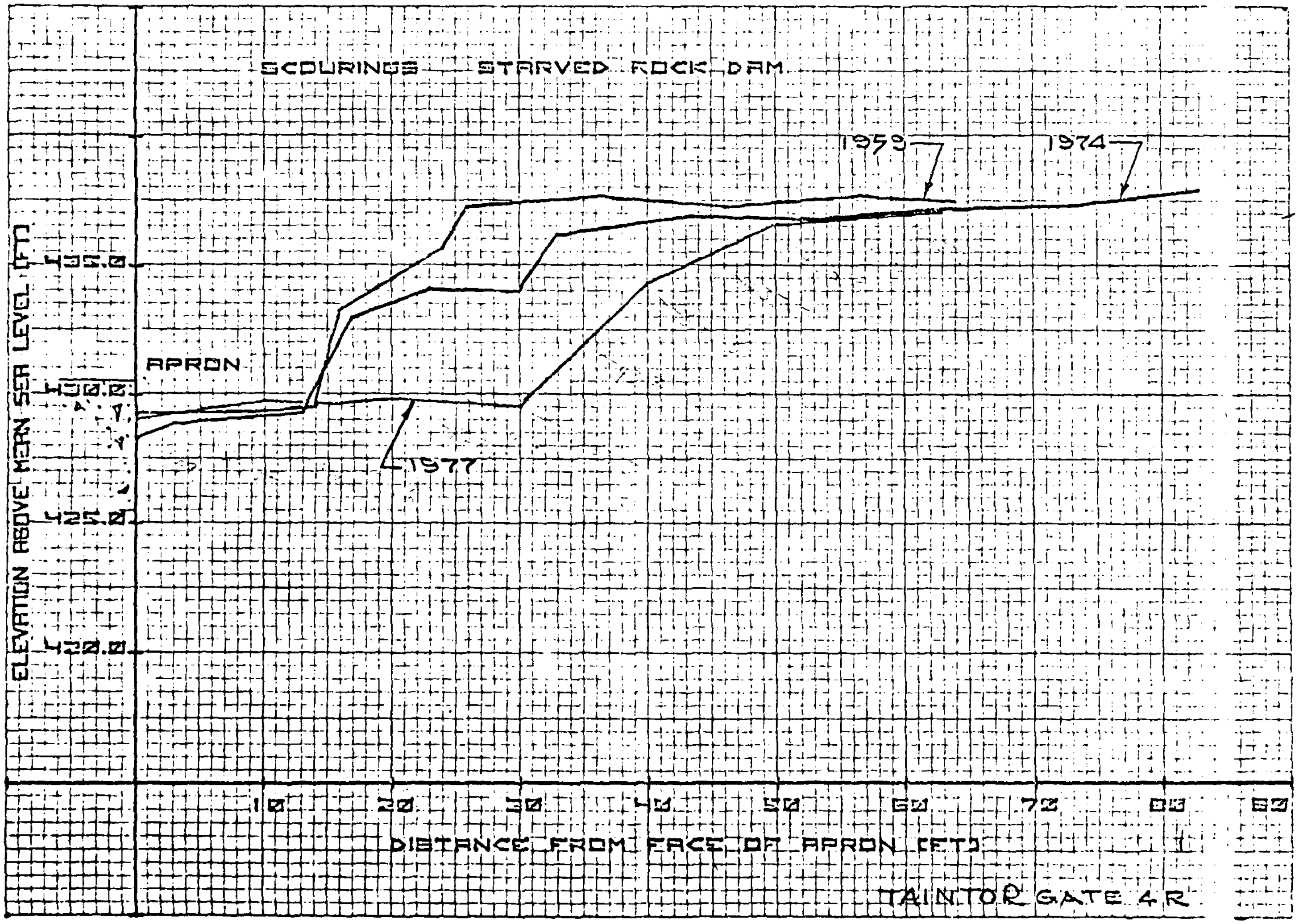

SCOURINGS STARVED ROCK DAM
1959
1974
APRON
1977
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 4 R

PLATE A36

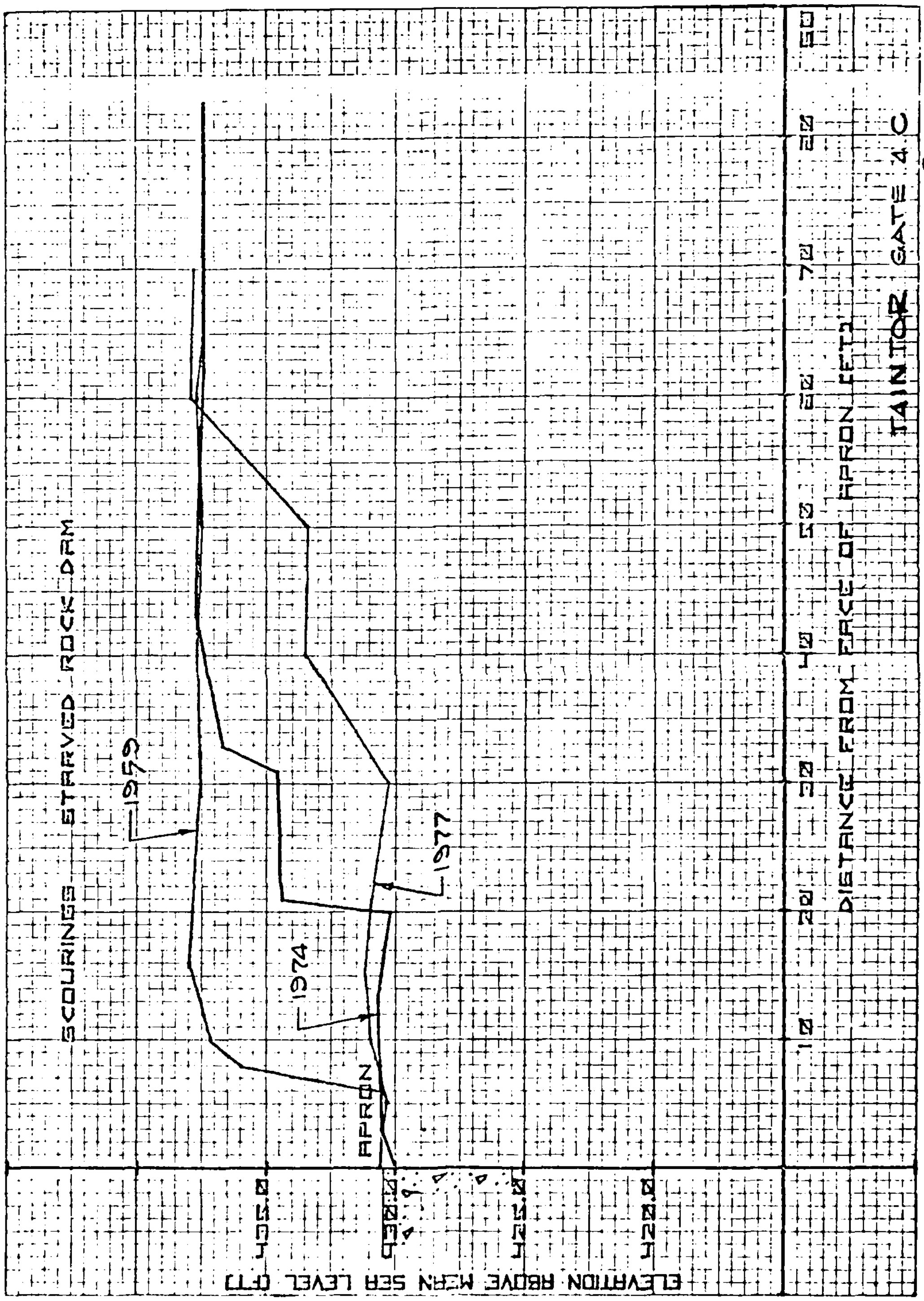
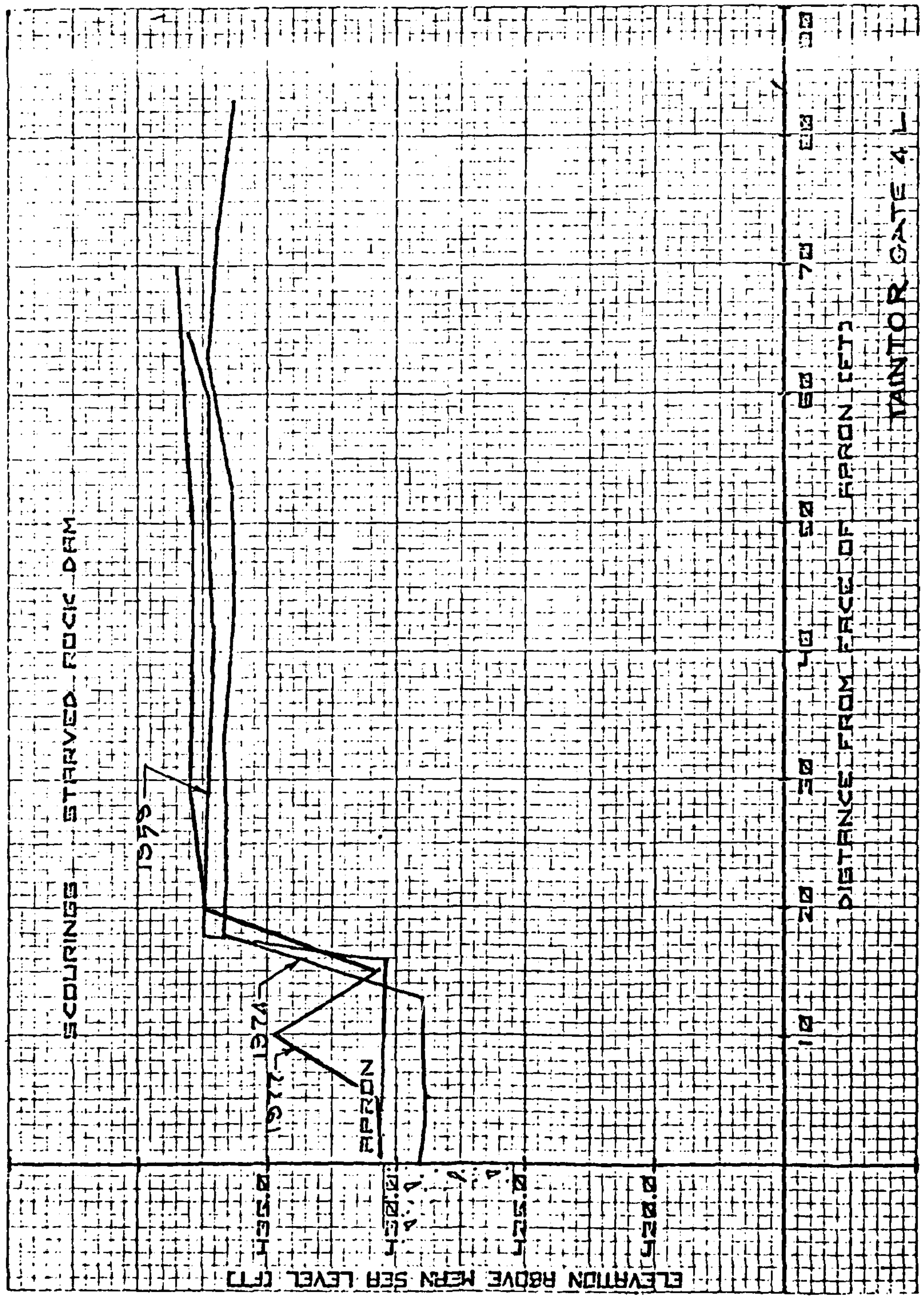
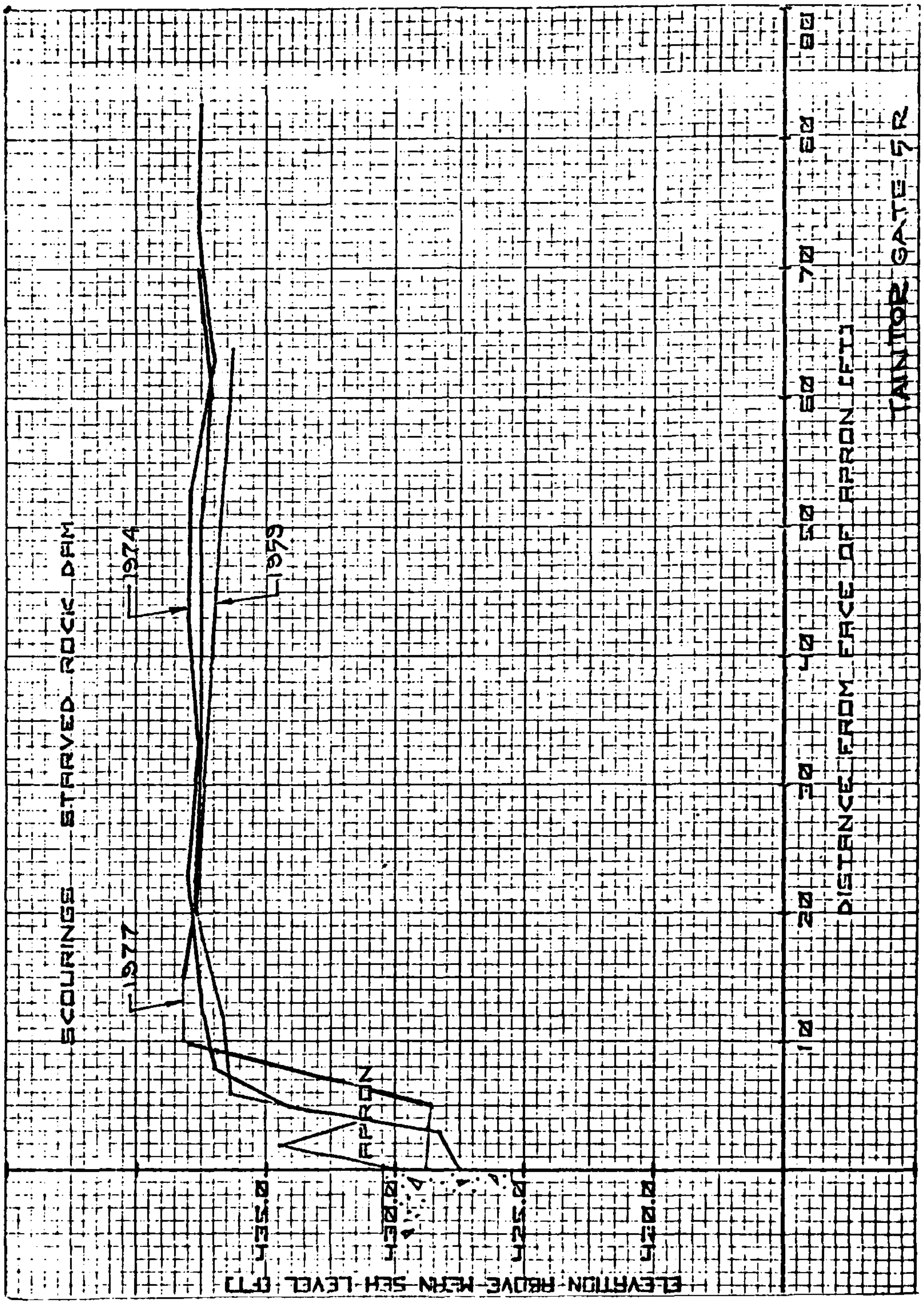

SCOURINGS STARVED ROCK DAM
TAINTOR GATE 4 C
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1959
1974
1977
APRON
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90

PLATE A37



SCOURINGS STARVED ROCK DAM
TAINTOR GATE 4 L
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1959
1974
1972
APRON
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90

PLATE A38


SCOURINGS STARVED ROCK DAM
TAINTOR GATE 5R
1974
1979
1977
APRON
10
20
30
40
50
60
70
80
DISTANCE FROM FACE OF APRON (FT)
435.0
430.0
425.0
420.0
ELEVATION ABOVE MEAN SEA LEVEL (FT)

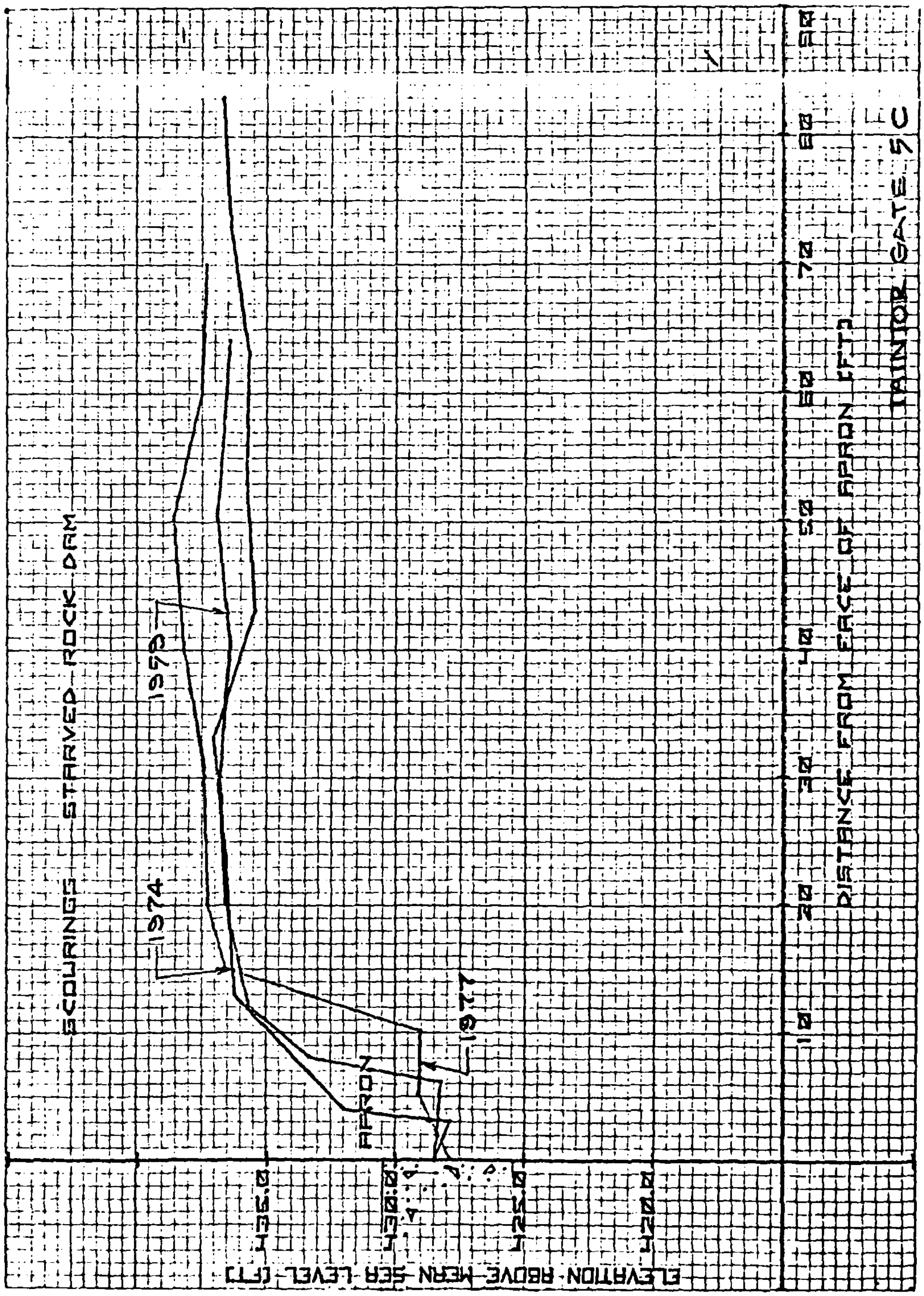

SCOURINGS - STARVED ROCK DAM
1974
1979
1977
APRON
435.0
430.0
425.0
420.0
ELEVATION ABOVE MEAN SEA LEVEL (FT)
10
20
30
40
50
60
70
80
90
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 5C

PLATE A40

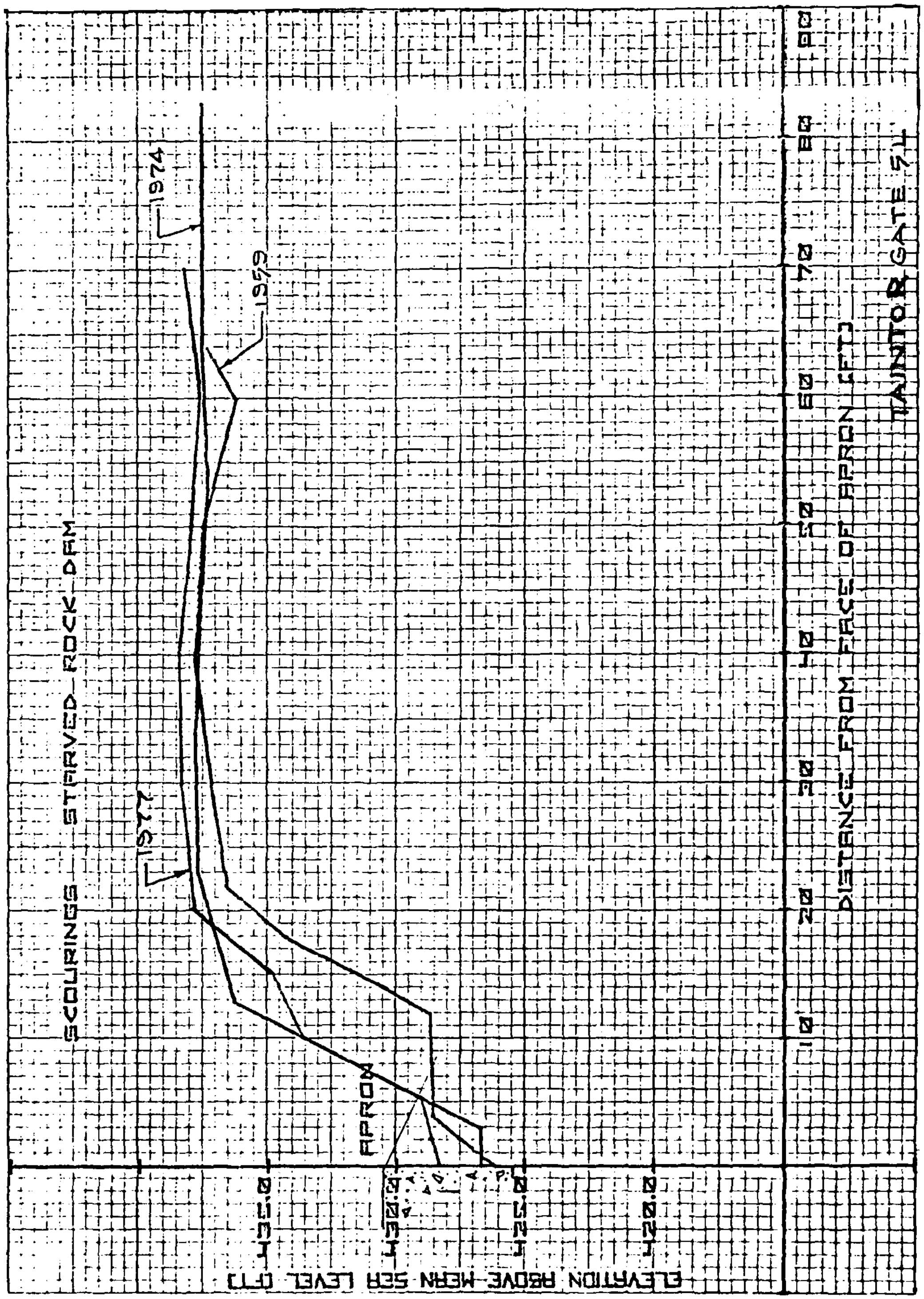

SCOURINGS - STARVED ROCK DAM
TAINTOR GATE 5L
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1974
1959
1977
APRON
10
20
30
40
50
60
70
80
90
435.0
430.0
425.0
420.0

PLATE A41

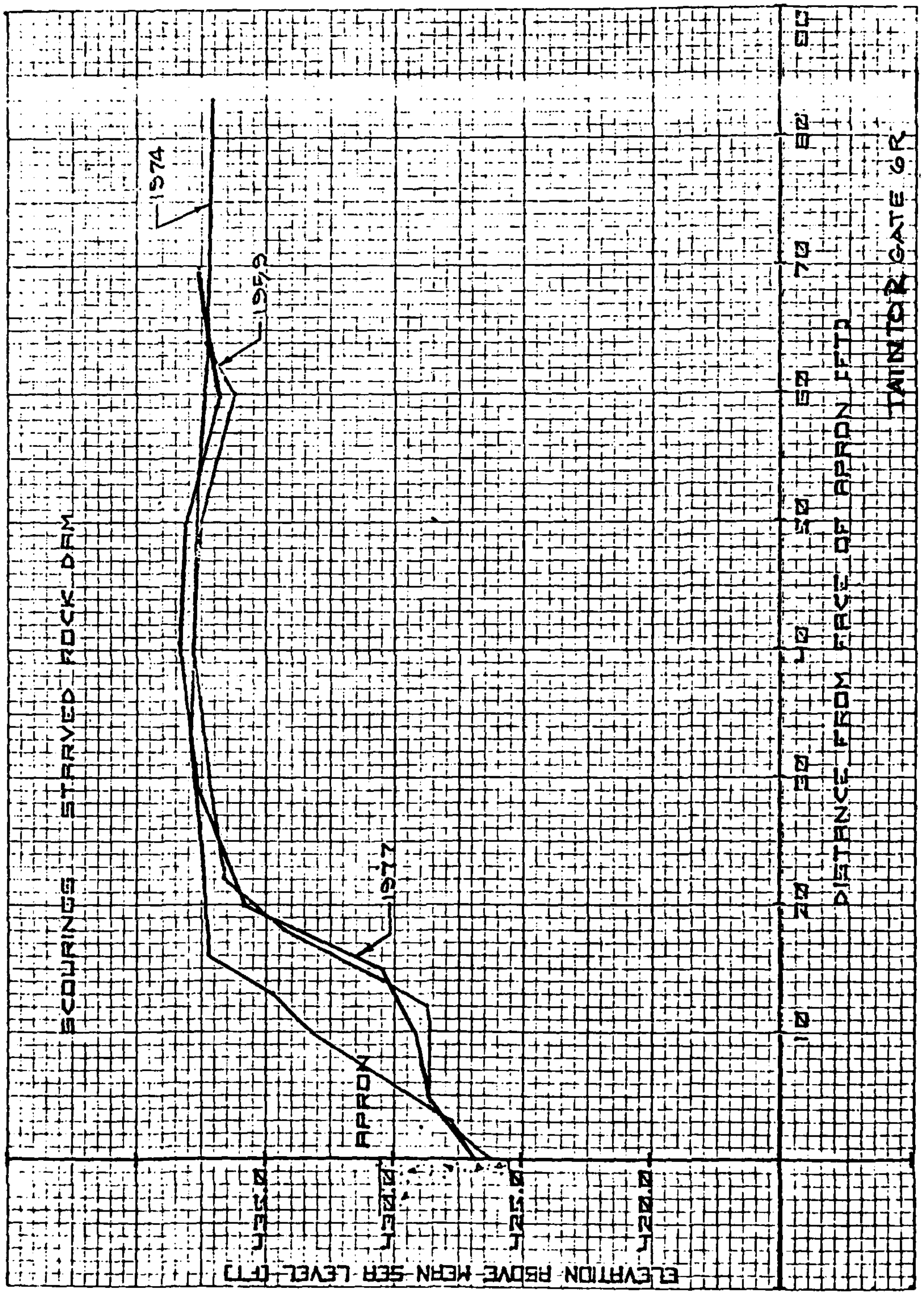
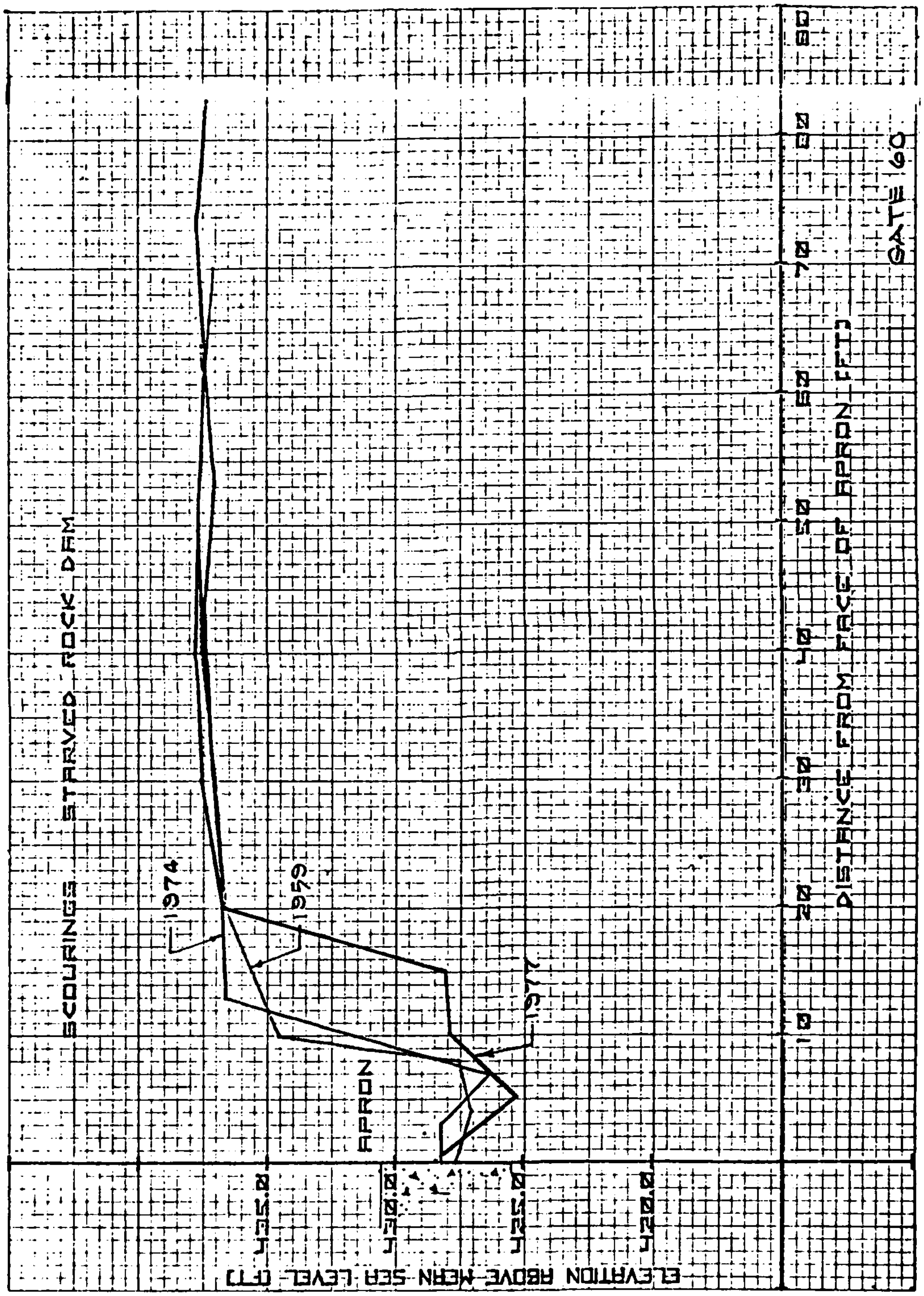

SCOURING STARVED ROCK DAM
1974
1959
1977
APRON
435.0
430.0
425.0
420.0
ELEVATION ABOVE MEAN SEA LEVEL (FT)
10
20
30
40
50
60
70
80
90
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 6R

PLATE A42



SCOURINGS STARVED ROCK DAM
GATE 60
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
APRON
1974
1959
1977
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90

PLATE A43

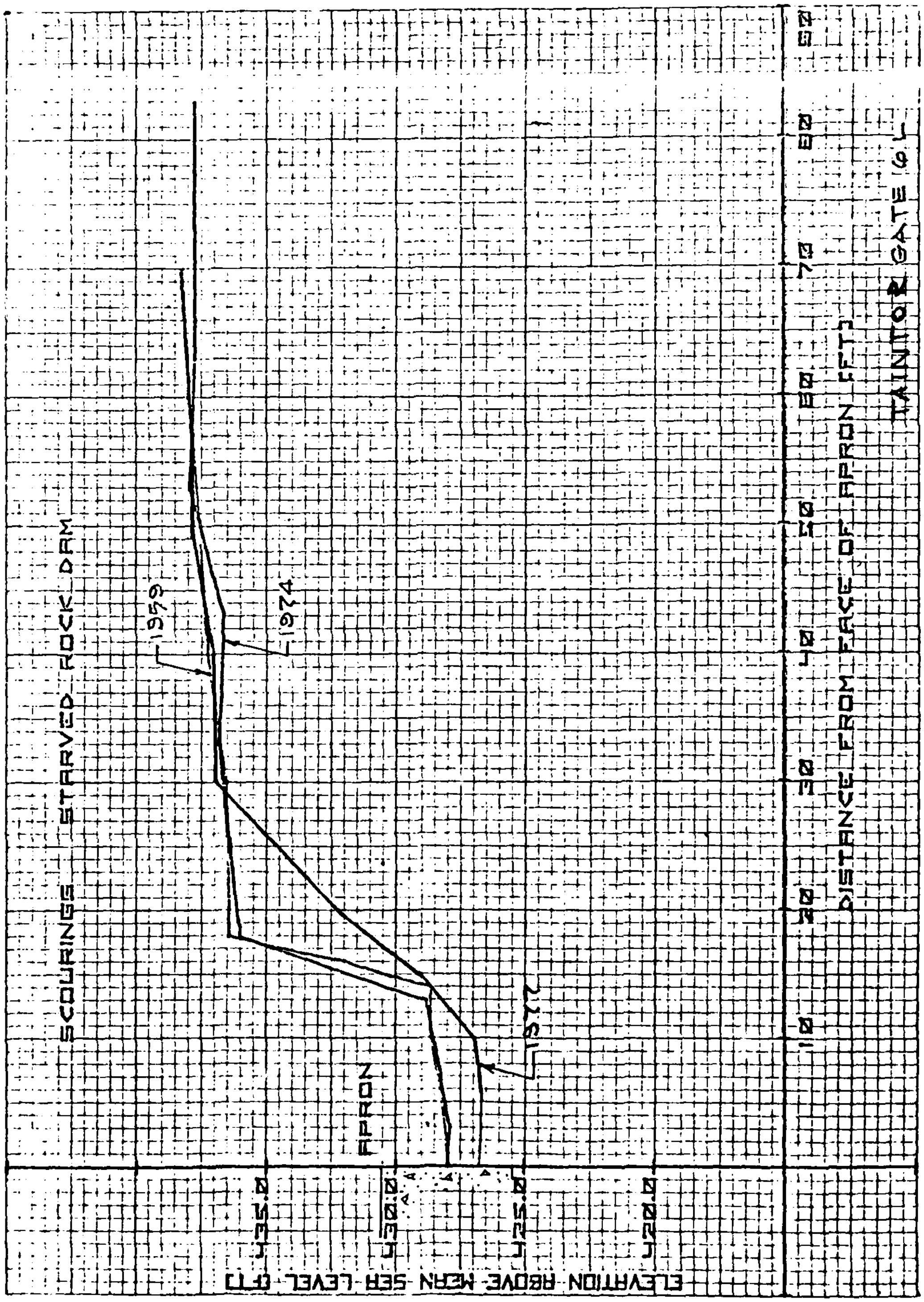

SCOURINGS STARVED ROCK DAM
TAINTOR GATE 6 L
1959
1974
1977
APRON
435.0
430.0
425.0
420.0
ELEVATION ABOVE MEAN SEA LEVEL (FT)
10
20
30
40
50
60
70
80
90
DISTANCE FROM FACE OF APRON (FT)

PLATE A44

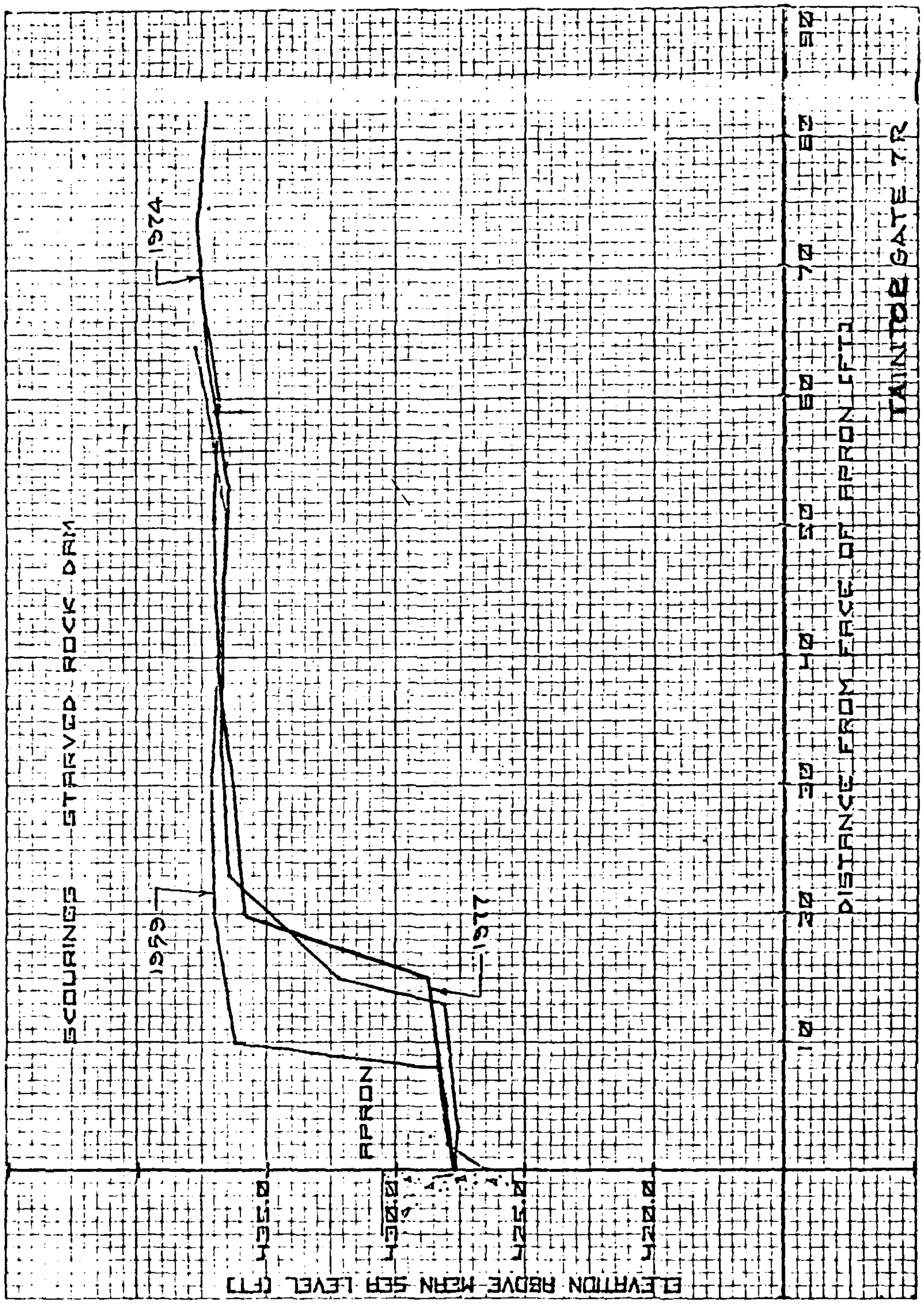

SCOURINGS — STARVED ROCK DAM
TAINTOR GATE 7R
1974
1959
1977
APRON
DISTANCE FROM FACE OF APRON (FT)
10
20
30
40
50
60
70
80
90
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0

PLATE A45

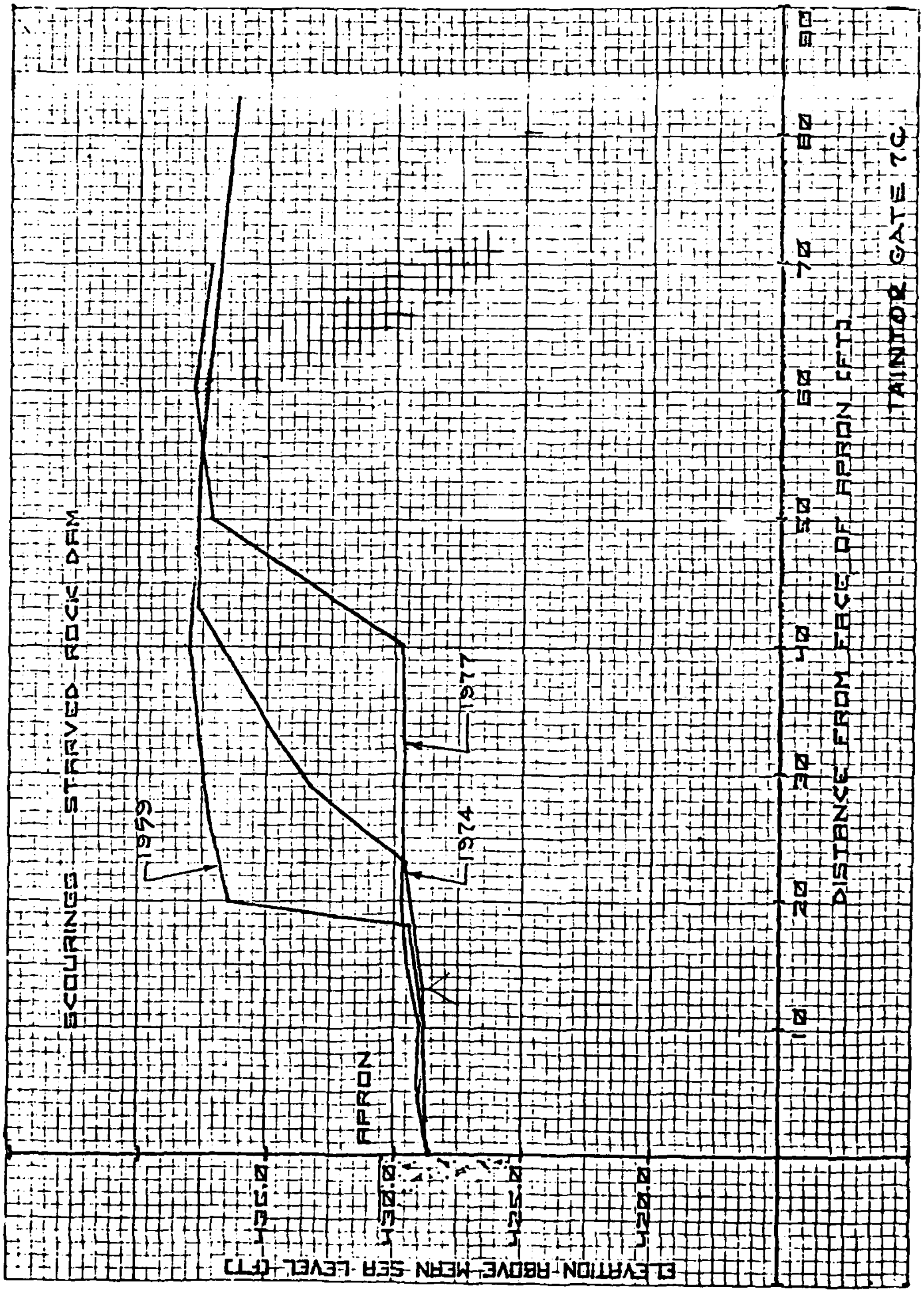

SCOURINGS – STARVED ROCK DAM
TAINTOR GATE 7C
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1959
1974
1977
APRON
10
20
30
40
50
60
70
80
90
435.0
430.0
425.0
420.0

PLATE A46

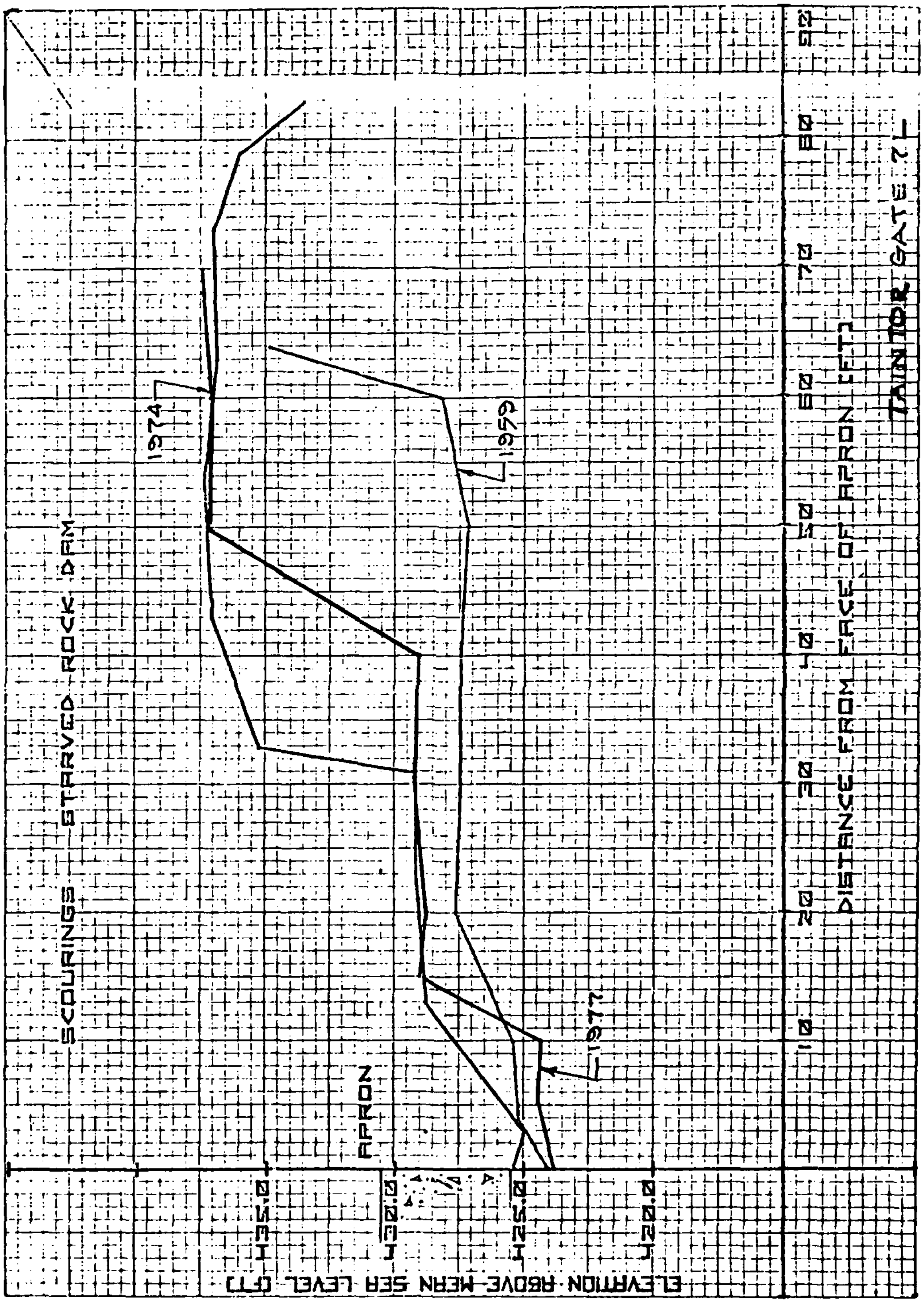

SCOURINGS — STARVED ROCK DAM
TAINTOR GATE 7
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1974
1959
1977
APRON
10
20
30
40
50
60
70
80
90
420.0
425.0
430.0
435.0

PLATE A47

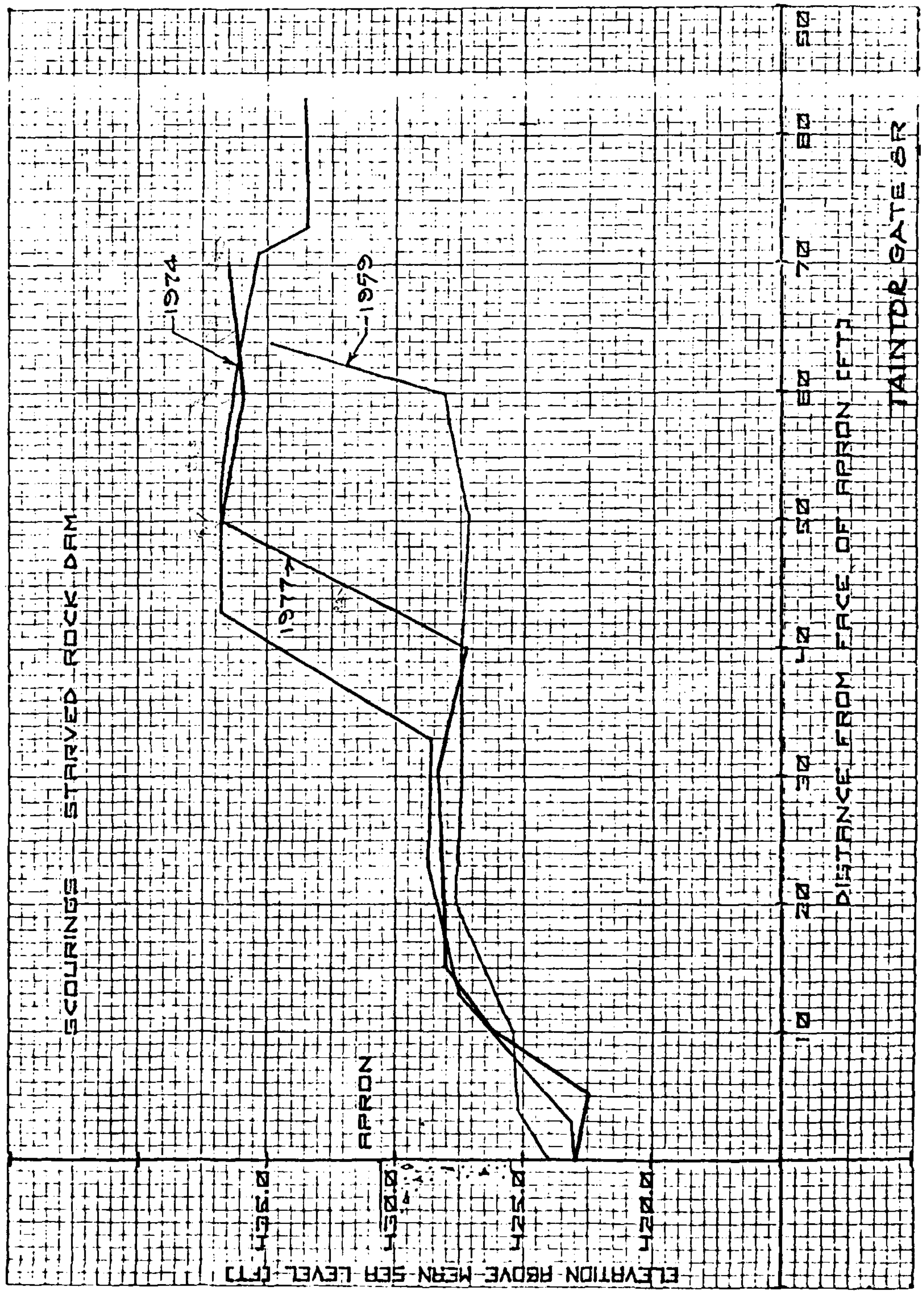
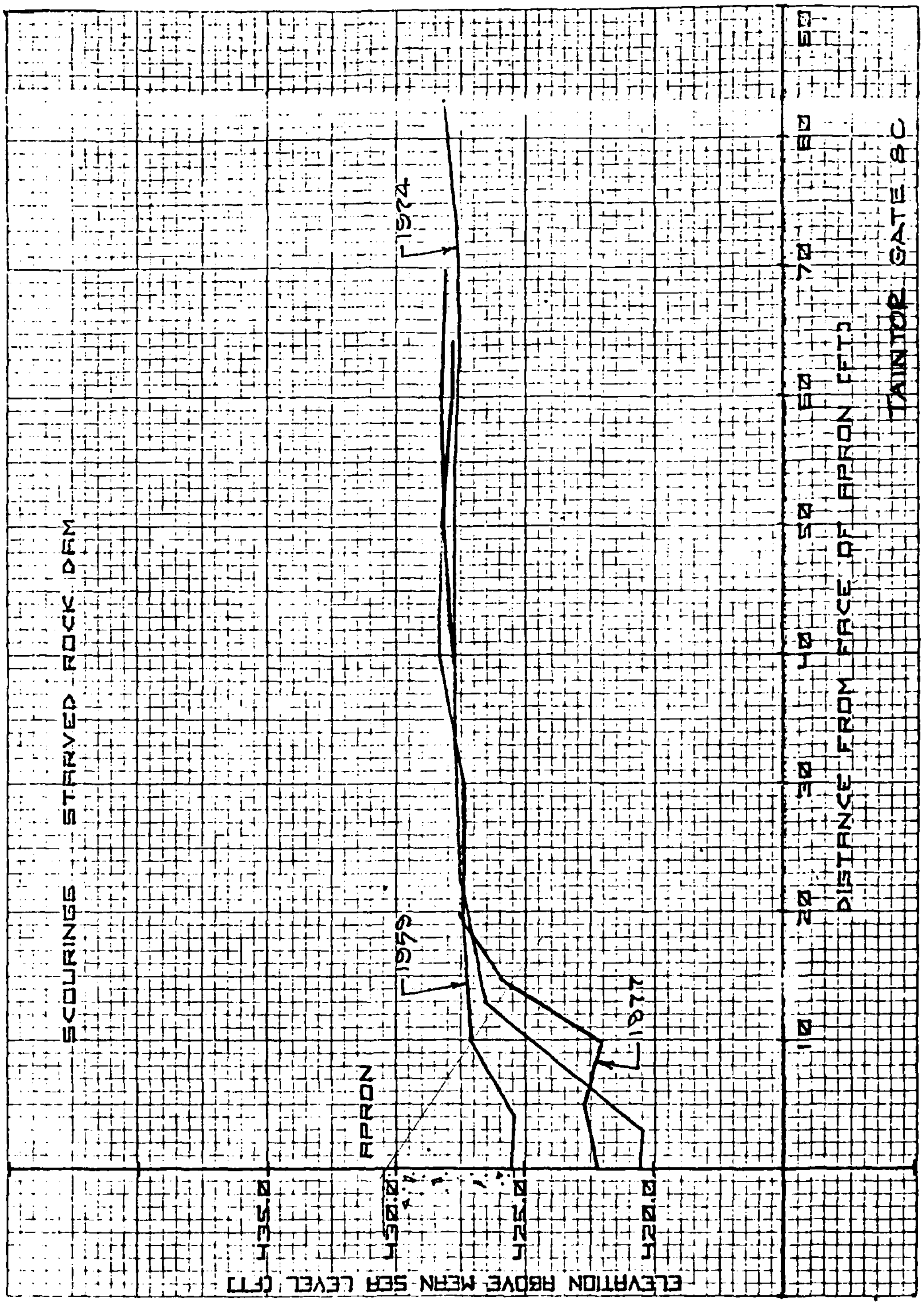

SCOURINGS STARVED ROCK DAM
1974
1979
1977
APRON
TAINTOR GATE 8R
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0
10
20
30
40
50
60
70
80
90

PLATE A48


SCOURINGS — STARVED ROCK DAM
TAINTOR GATE 8C
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
APRON
1974
1959
1977
10
20
30
40
50
60
70
80
90
420.0
425.0
430.0
435.0

AD-A085 584 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/13
CONCRETE AND ROCK TESTS, MAJOR REHABILITATION OF STARVED ROCK L--ETC(U)
APR 80 R L STOWE, B A PAVLOV
UNCLASSIFIED WES/MP/SL-80-6 NL

3 OF 3
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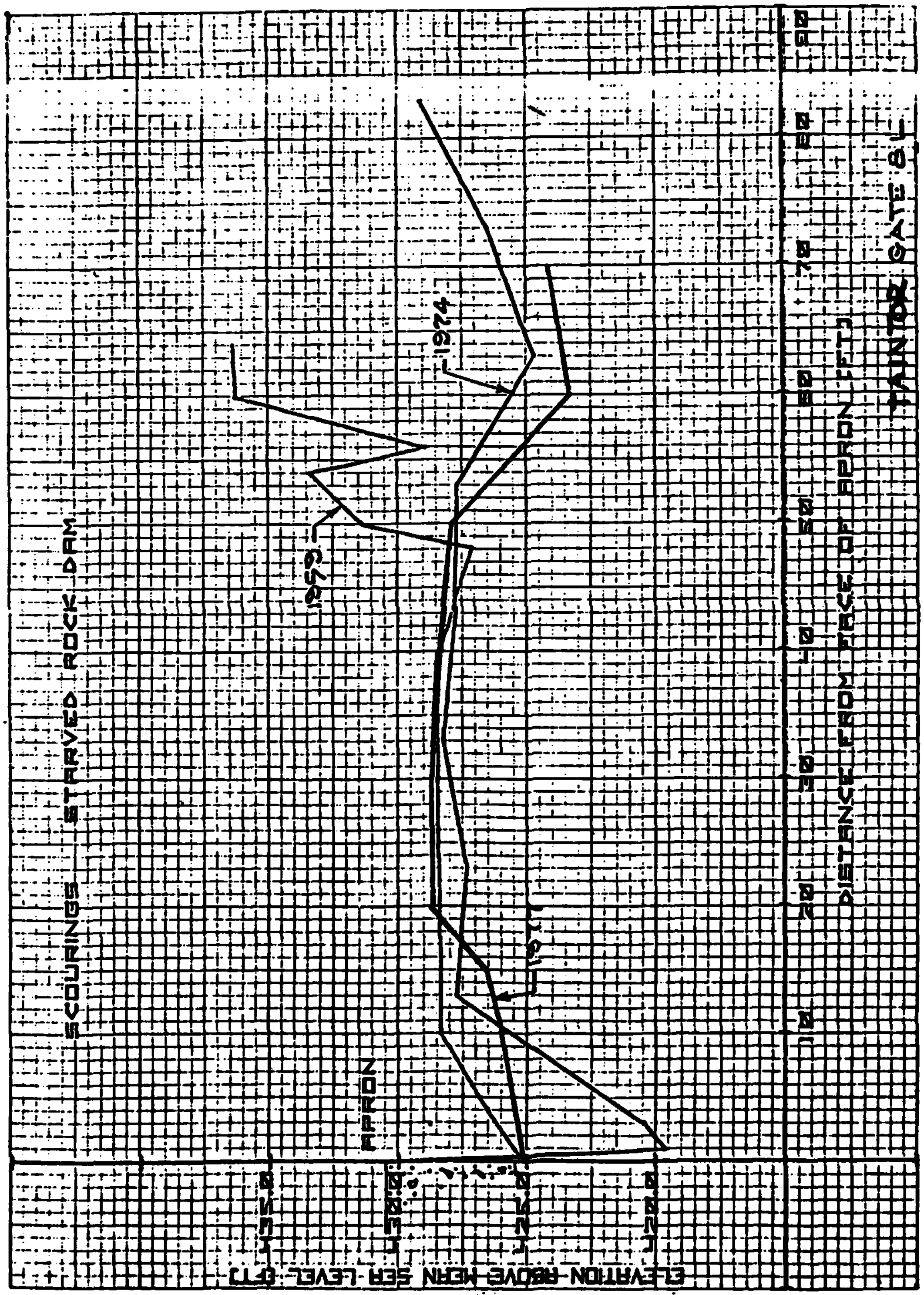
SCOURINGS STARVED ROCK DAM
TAINTOR GATE 8
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
1959
1974
APRON
10
20
30
40
50
60
70
80
90
422.0
425.0
428.0
431.0

PLATE A50

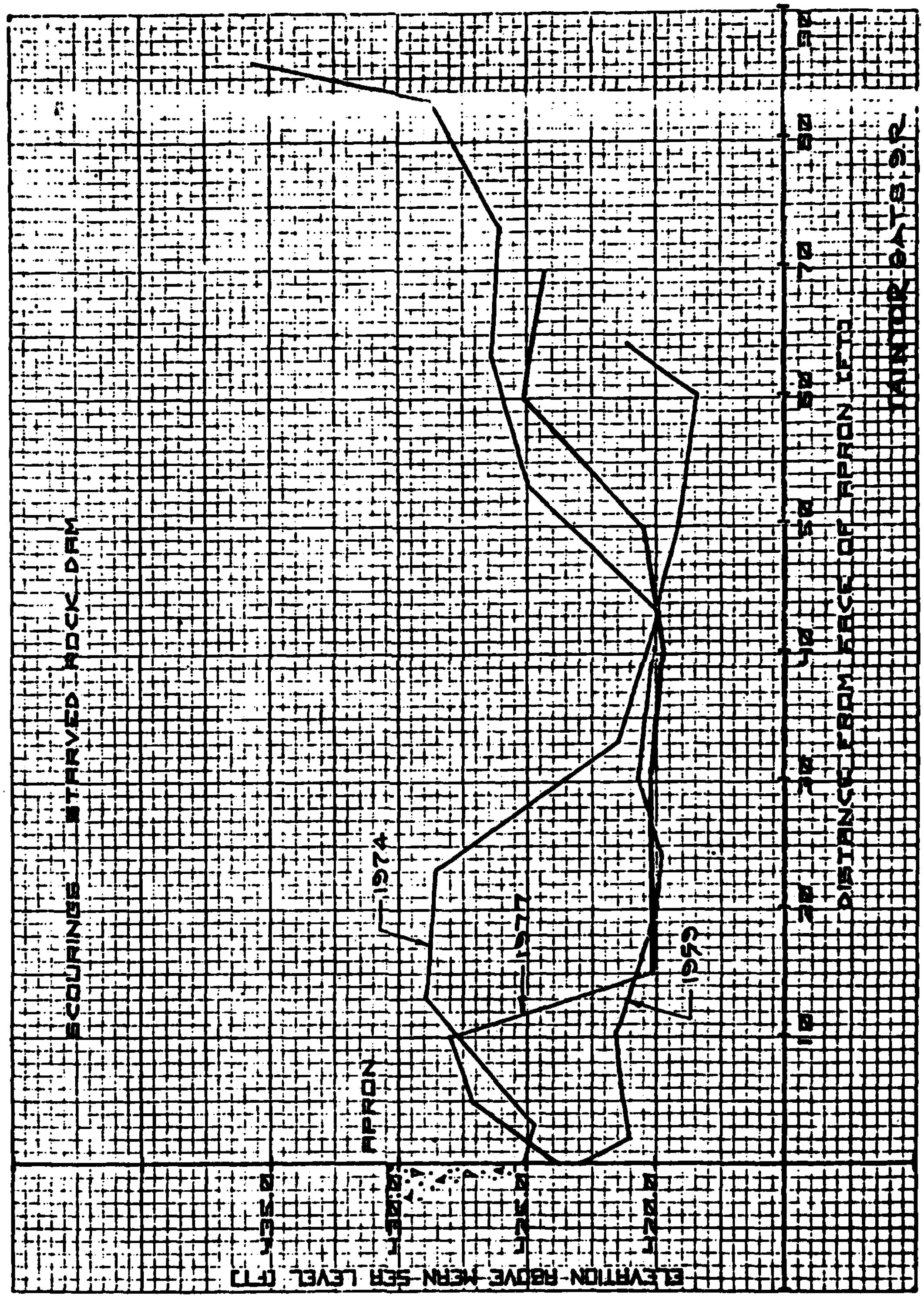
SCOURINGS STARVED ROCK DAM
TAINTOR GATE 9 R
DISTANCE FROM FACE OF APRON (FT)
10
20
30
40
50
60
70
80
90
ELEVATION ABOVE MEAN SEA LEVEL (FT)
435.0
430.0
425.0
420.0
APRON
1974
1977
1959

PLATE A51

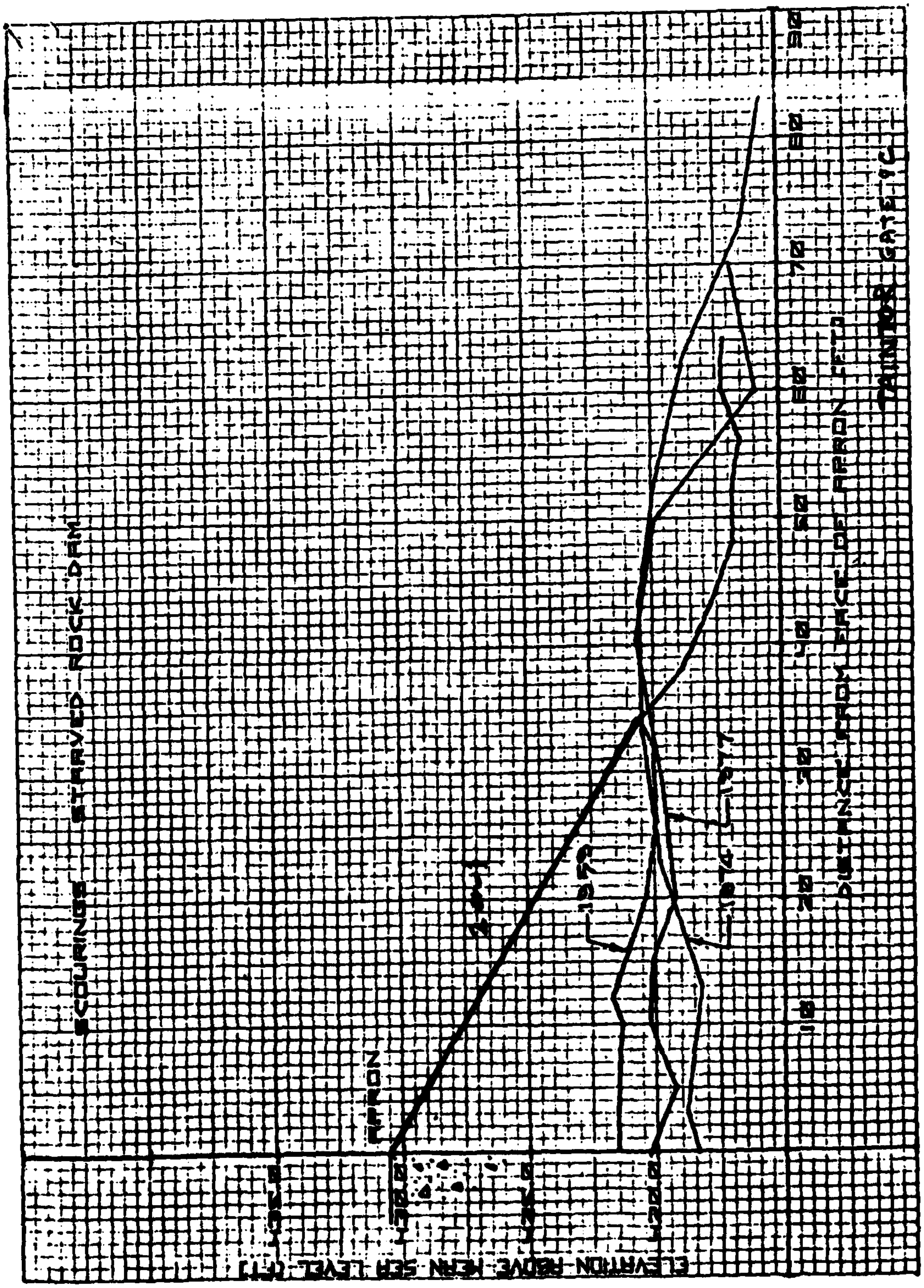
SCOURINGS STARVED ROCK DAM
TAINTOR GATE 1C
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
APRON
1972
1974
1977
10
20
30
40
50
60
70
80
90

PLATE A52

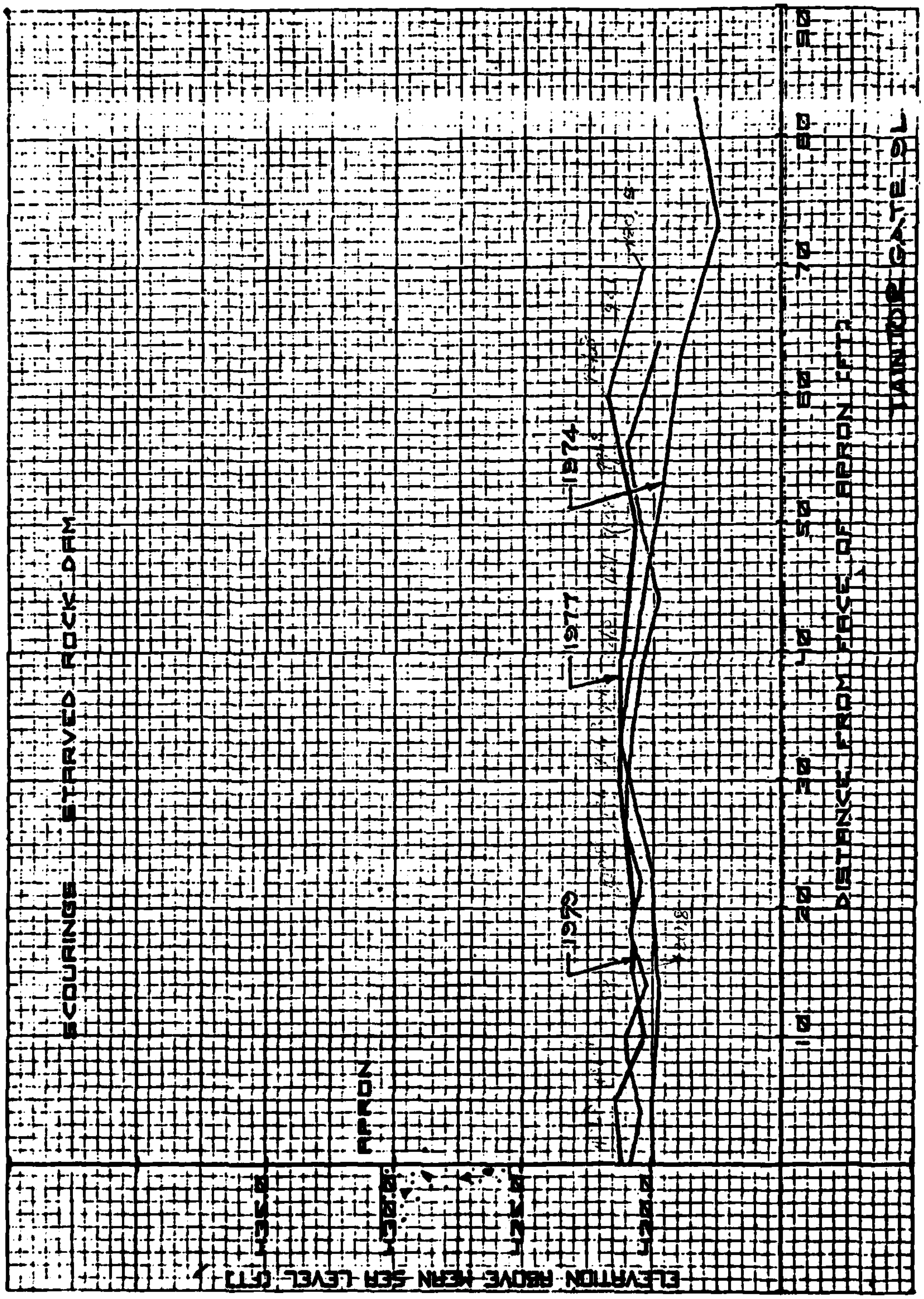
SCOURINGS STARVED ROCK DAM
TAINTOR GATE 9L
ELEVATION ABOVE MEAN SEA LEVEL (FT)
DISTANCE FROM FACE OF APRON (FT)
APRON
1974
1977
1979
10
20
30
40
50
60
70
80
90

PLATE A53

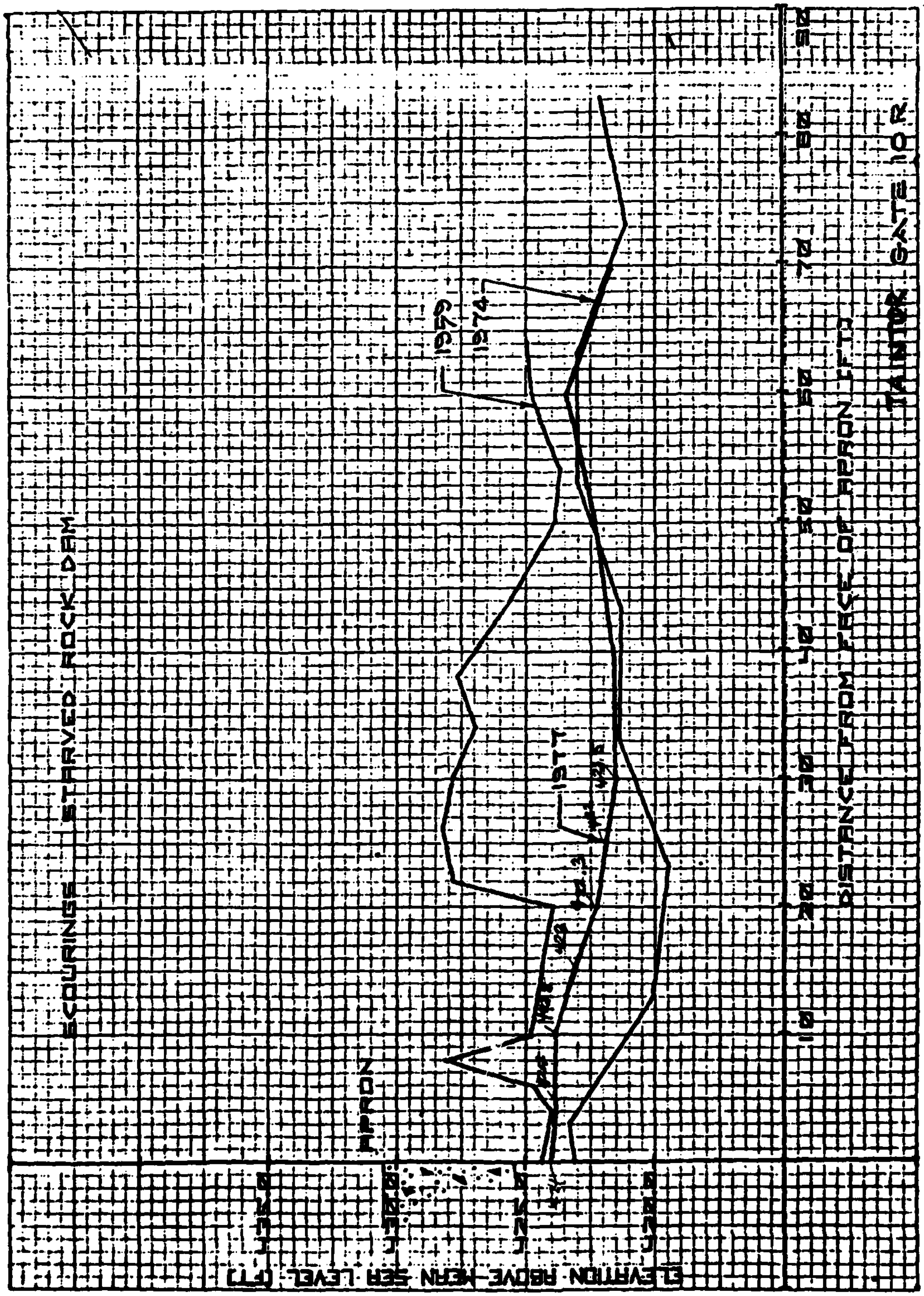
SCOURINGS STARVED ROCK DAM
TAINTER GATE 10R
DISTANCE FROM FACE OF APRON (FT)
ELEVATION ABOVE MEAN SEA LEVEL (FT)
APRON
1979
1974
1977
10
20
30
40
50
60
70
80
90

PLATE A54

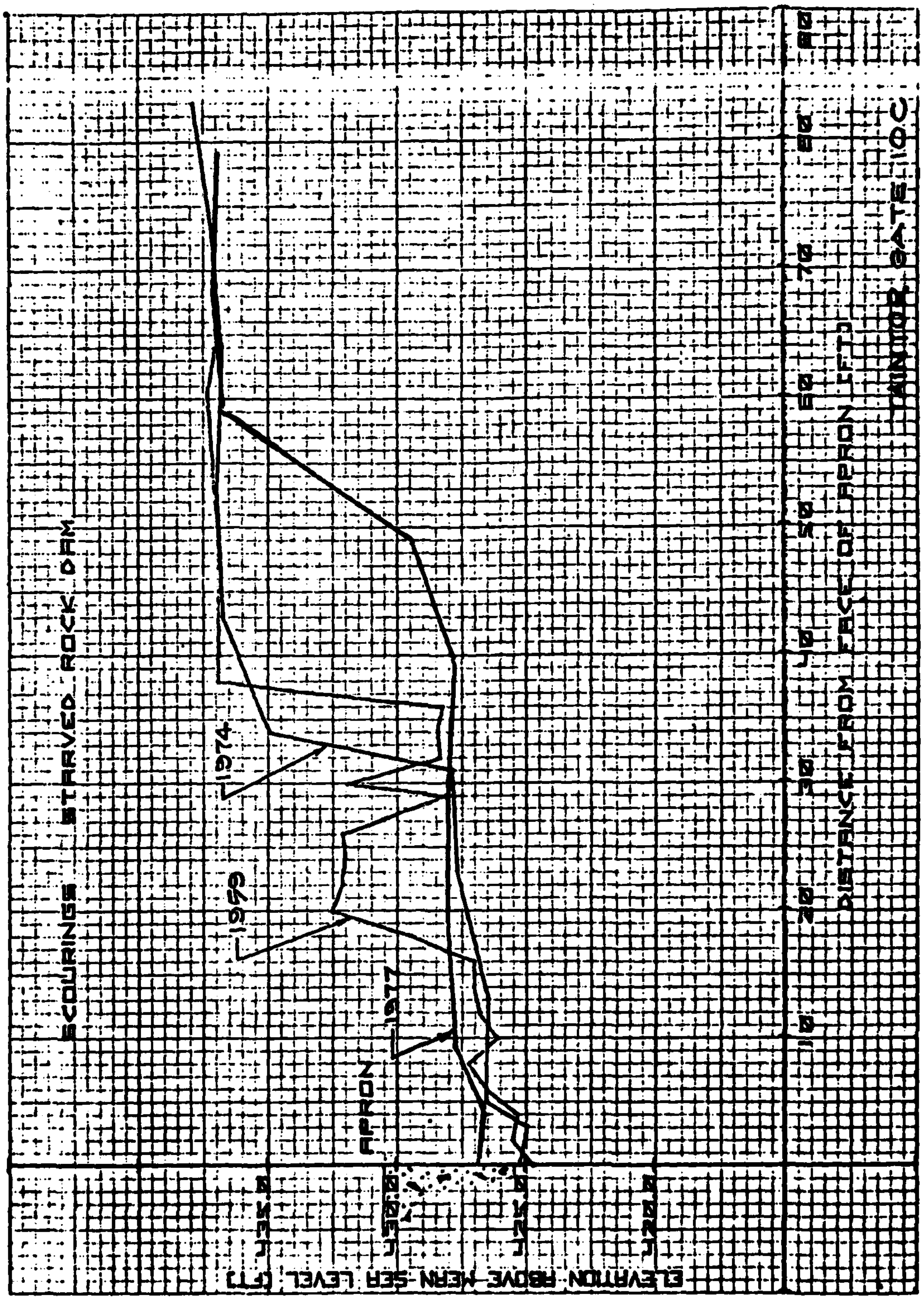
SCOURINGS STARVED ROCK DAM
TAINTOR GATE 10C
1974
1979
1977
APRON
10
20
30
40
50
60
70
80
90
DISTANCE FROM FACE OF APRON (FT)
435
430
425
420
ELEVATION ABOVE MEAN SEA LEVEL (FT)

PLATE A55

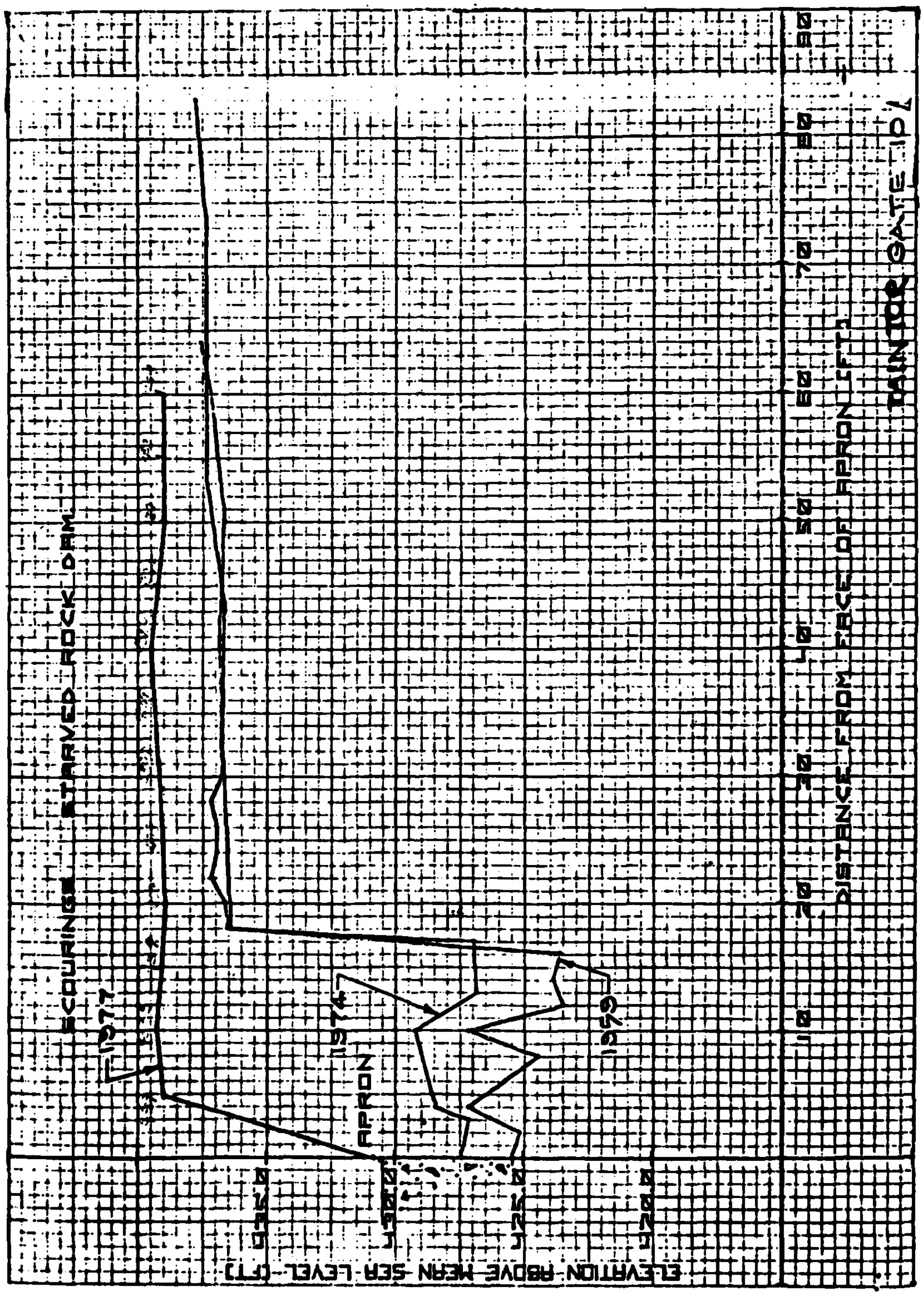
SCOURINGS STARVED ROCK DAM
1977
1974
1969
APRON
DISTANCE FROM FACE OF APRON (FT)
TAINTOR GATE 10
ELEVATION ABOVE MEAN SEA LEVEL (FT)

PLATE A56

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Stowe, Richard L
Concrete and rock tests, major rehabilitation of Starved Rock Lock and Dam, Illinois Waterway, Chicago District, Phase II compliance, scour detection / by R. L. Stowe, B. A. Pavlov. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.
61, [7] p., [66] leaves of plates : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; SL-80-6)
Prepared for U. S. Army Engineer District, Chicago, Chicago, Illinois.
References: p. 61.

1. Concrete cores. 2. Concrete tests. 3. Core drilling. 4. Rock cores. 5. Rock foundations. 6. Rock tests (Laboratory). 7. Starved Rock Lock and Dam. I. Pavlov, Barbara A., joint author. II. United States. Army. Corps of Engineers. Chicago District. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; SL-80-6.
TA7.W34m no.SL-80-6